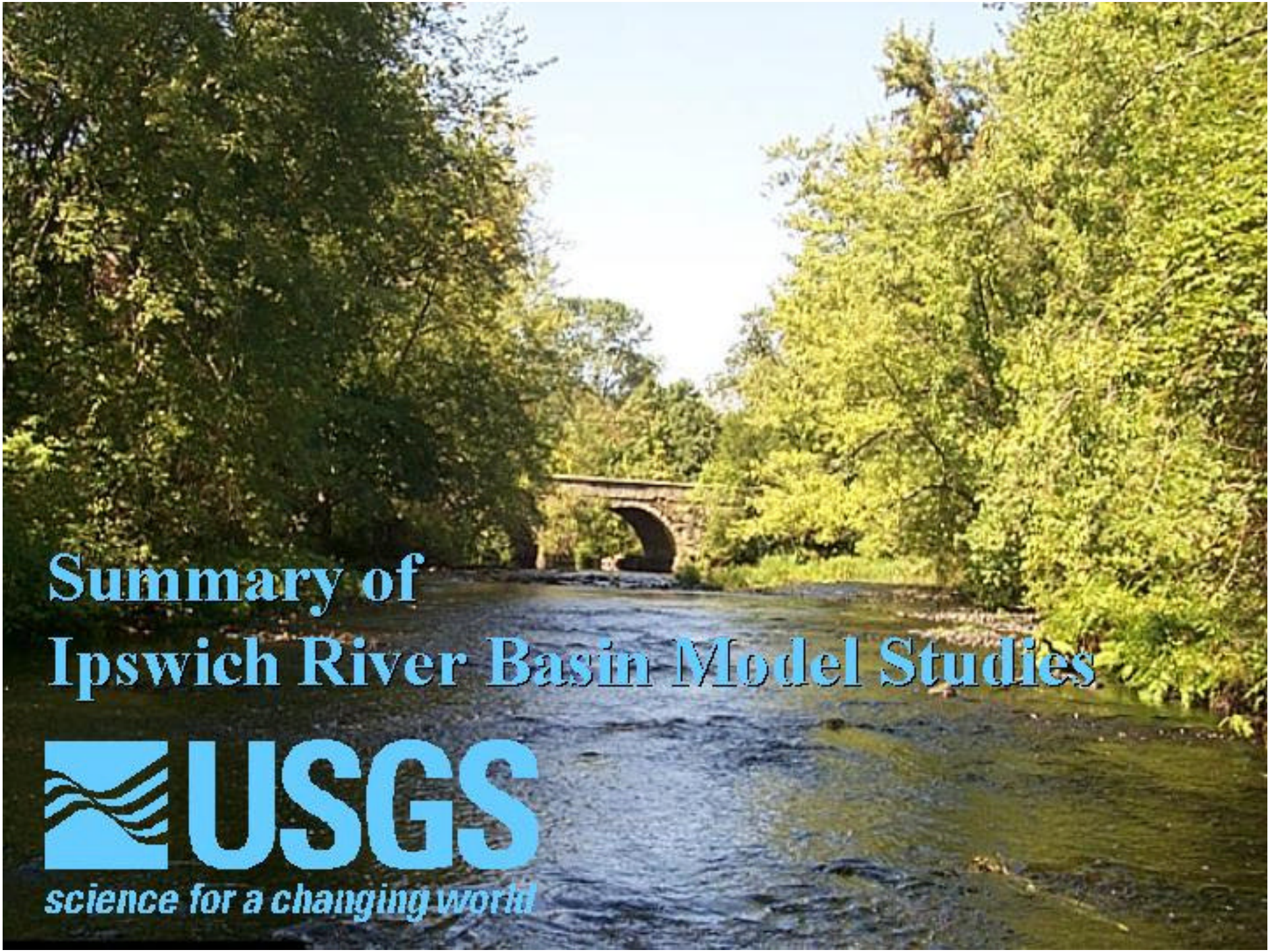
Summary of
Ipswich River Basin Model Studies
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Development of the HSPF Precipitation-Runoff model

"To enable users to better manage water resources by providing a tool for analyzing effects on streamflow of various land and water use practices"

"Our consultants think [the USGS study] is dead on arrival" Boston Globe 8/1/1999 by Coco McCabe

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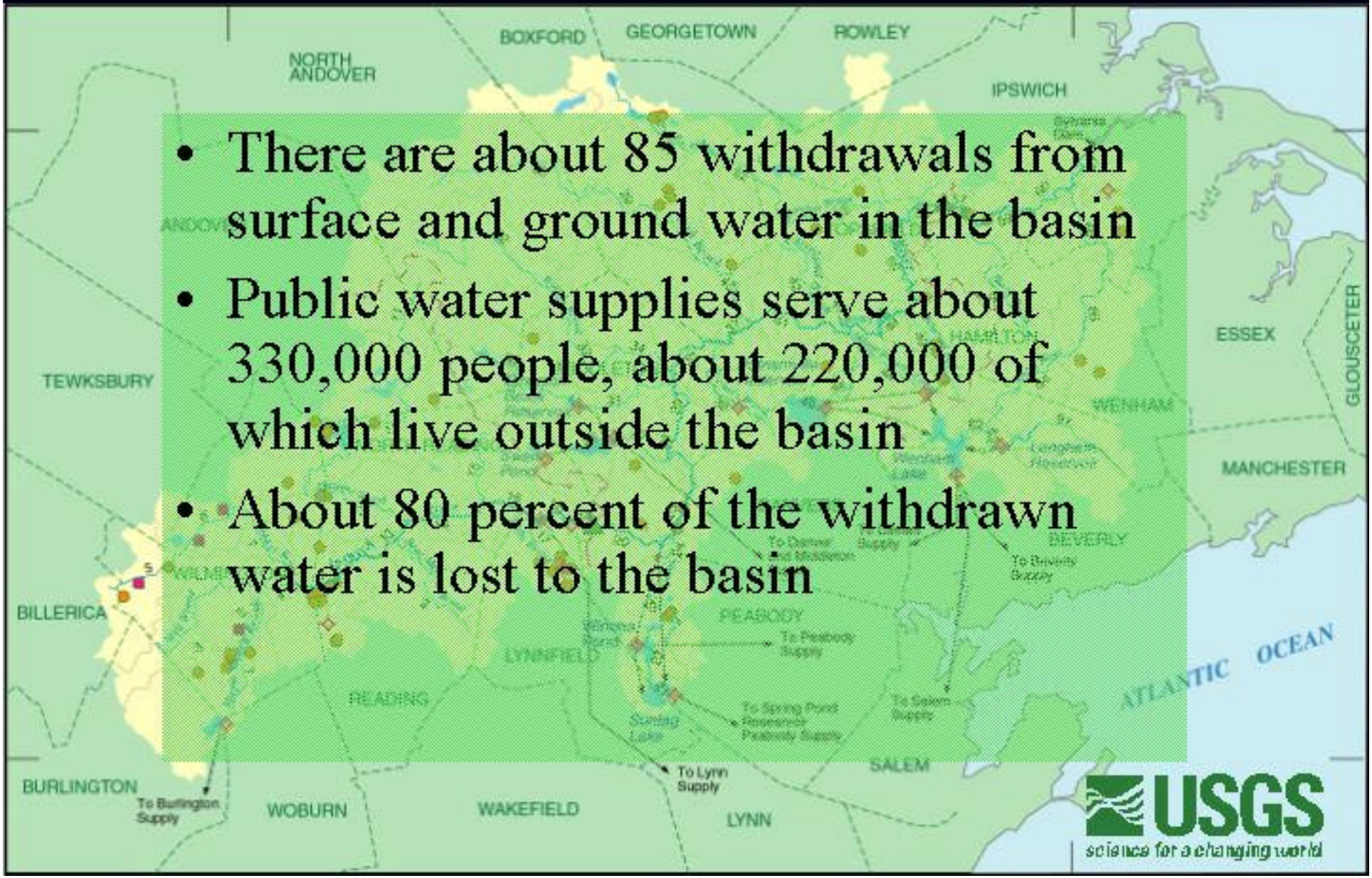
SUBBASINS, WITHDRAWALS, and MODEL REACHES



- There are about 85 withdrawals from surface and ground water in the basin
- Public water supplies serve about 330,000 people, about 220,000 of which live outside the basin
- About 80 percent of the withdrawn water is lost to the basin

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Model Requirements
Components of the Water Budget

- Hydrologic response to land use changes
- Ground-water withdrawals
- Surface-water withdrawals
- Areas on septic systems
- Streamflow dynamics of different water management strategies under long-term meterologic conditions

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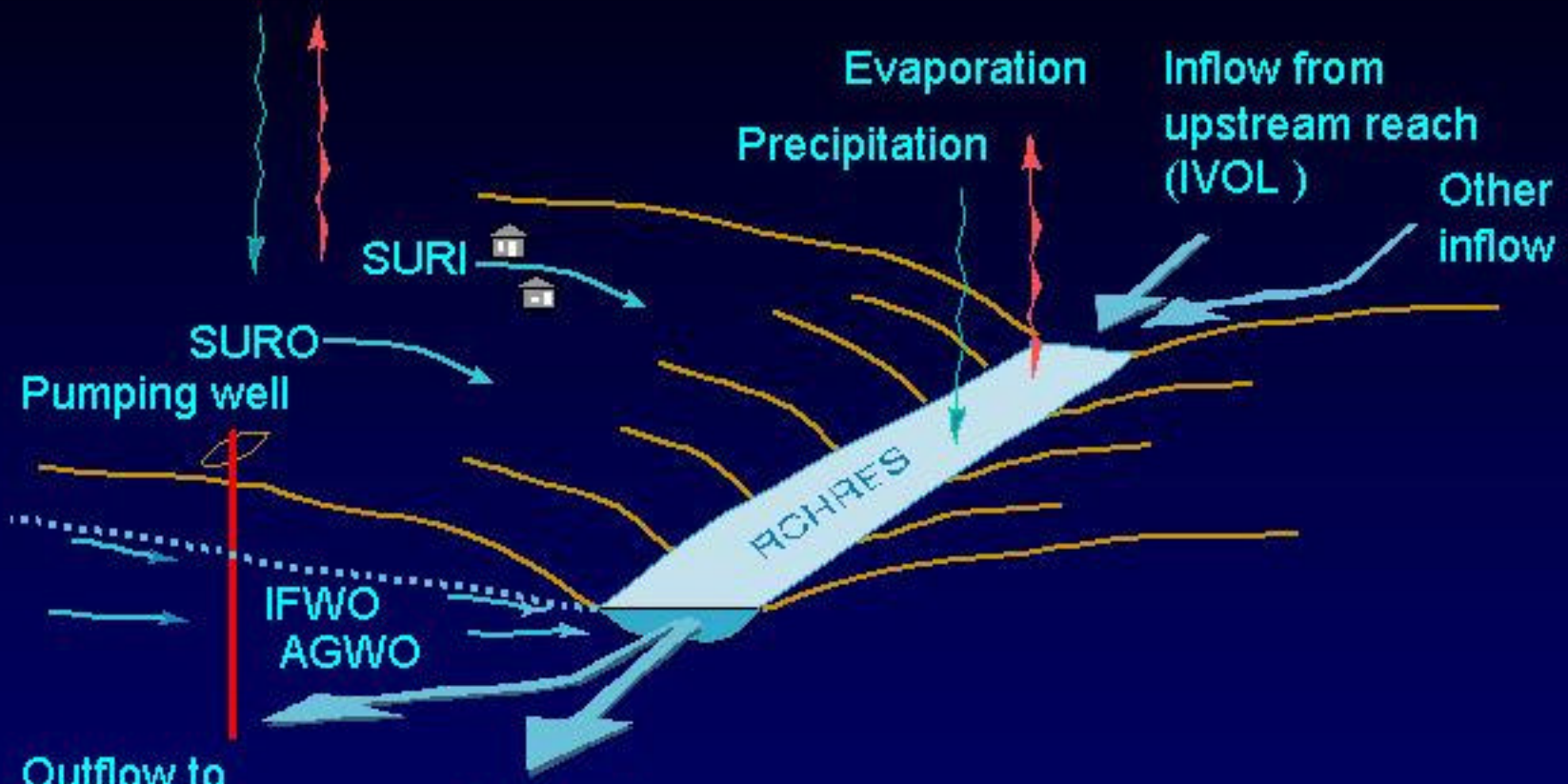
Conceptual Schematic of HSPF



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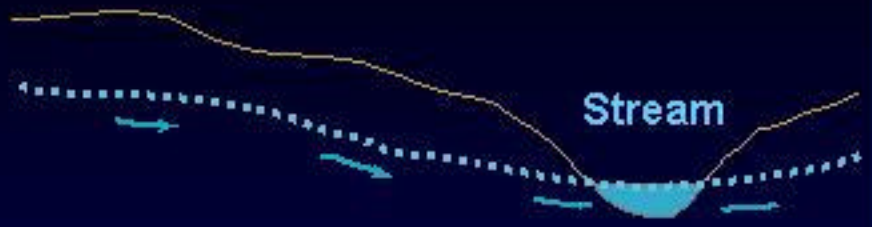
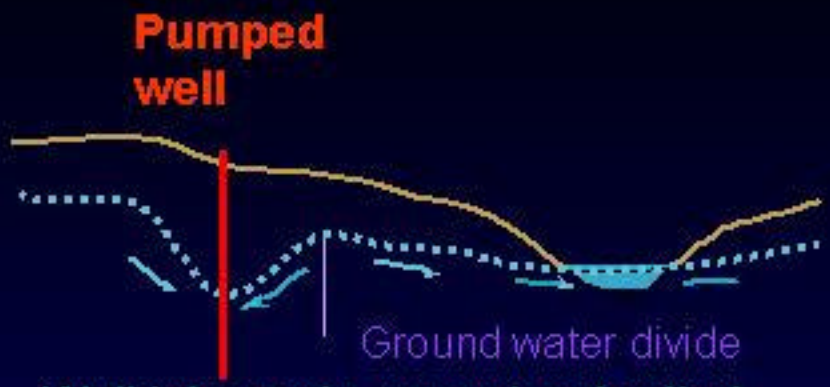
Streamflow Depletion
STRMDEPL -



Ground water discharges to stream

Captured recharge



Well intercepts ground water that would have discharged to the stream

Induced infiltration

Well intercepts ground water and induces infiltration from the stream

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Low recharge

Well intercepts ground water, but also takes water from storage to satisfy demands

Wenham well

DEP No 3119-000-05G & 3119000-06G
300 & 720 feet from stream, respectively

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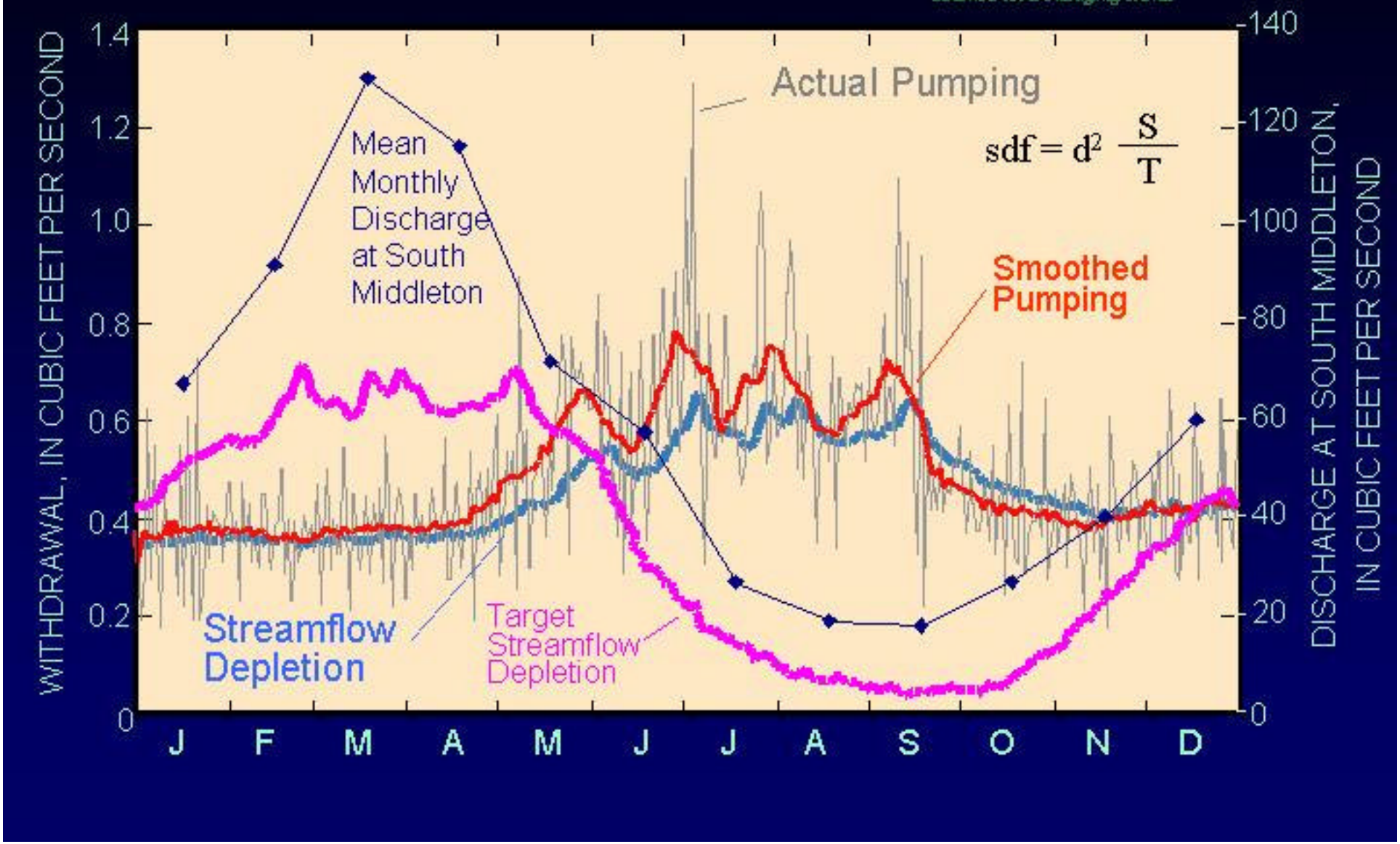


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1 Stopped all withdrawals, 1989-93 period
2 Stopped only GW withdrawals, 1989-93 period
3 Stopped only SW withdrawals, 1989-93 period
4 Long-term (1961-95) as calibrated
5 Long-term, revert land to undeveloped and no withdrawals
6 Long-term, with average 1989-93 withdrawals

Flow Duration- Scenarios 1-3

1989-93 Calibration period

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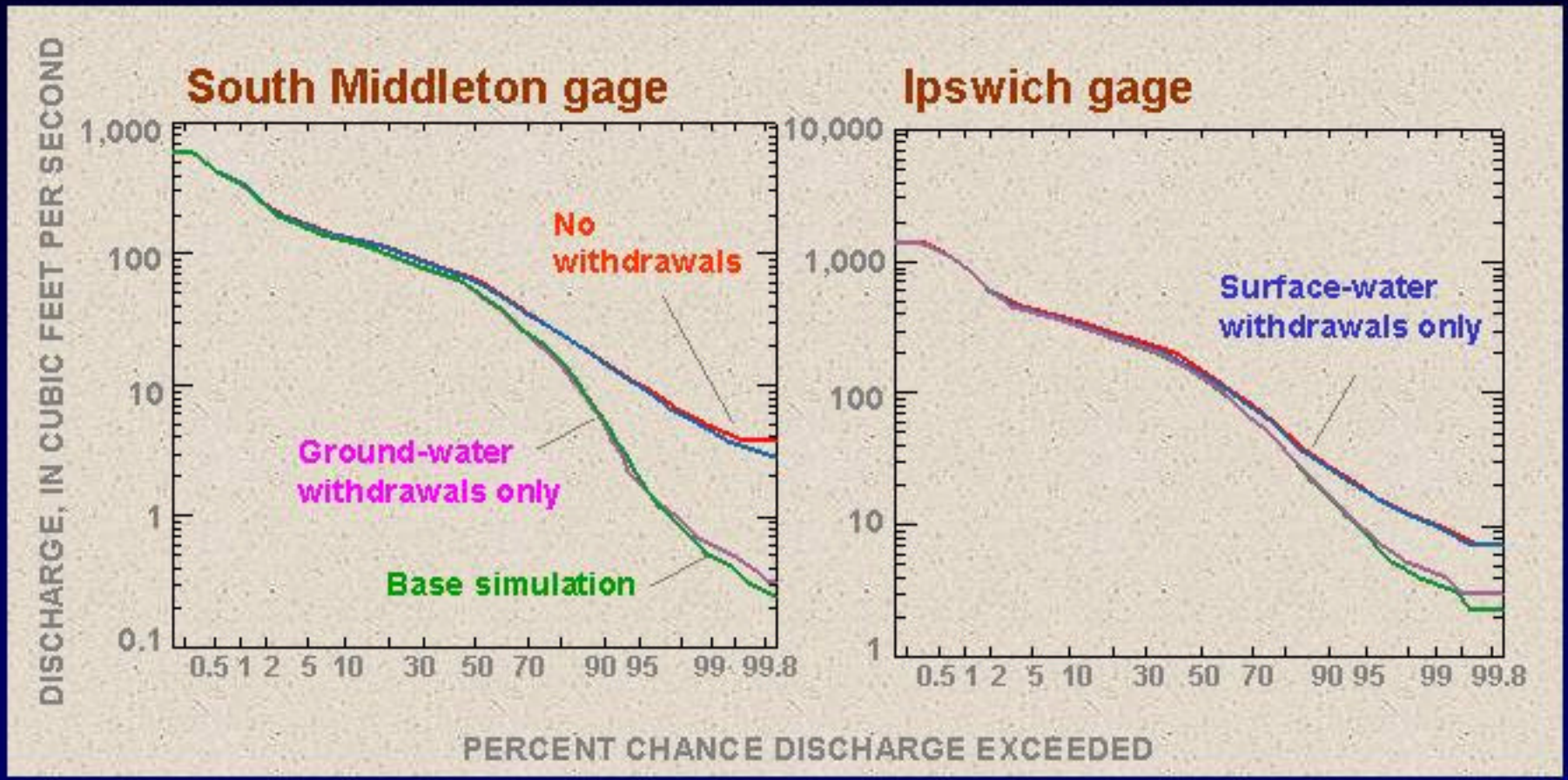
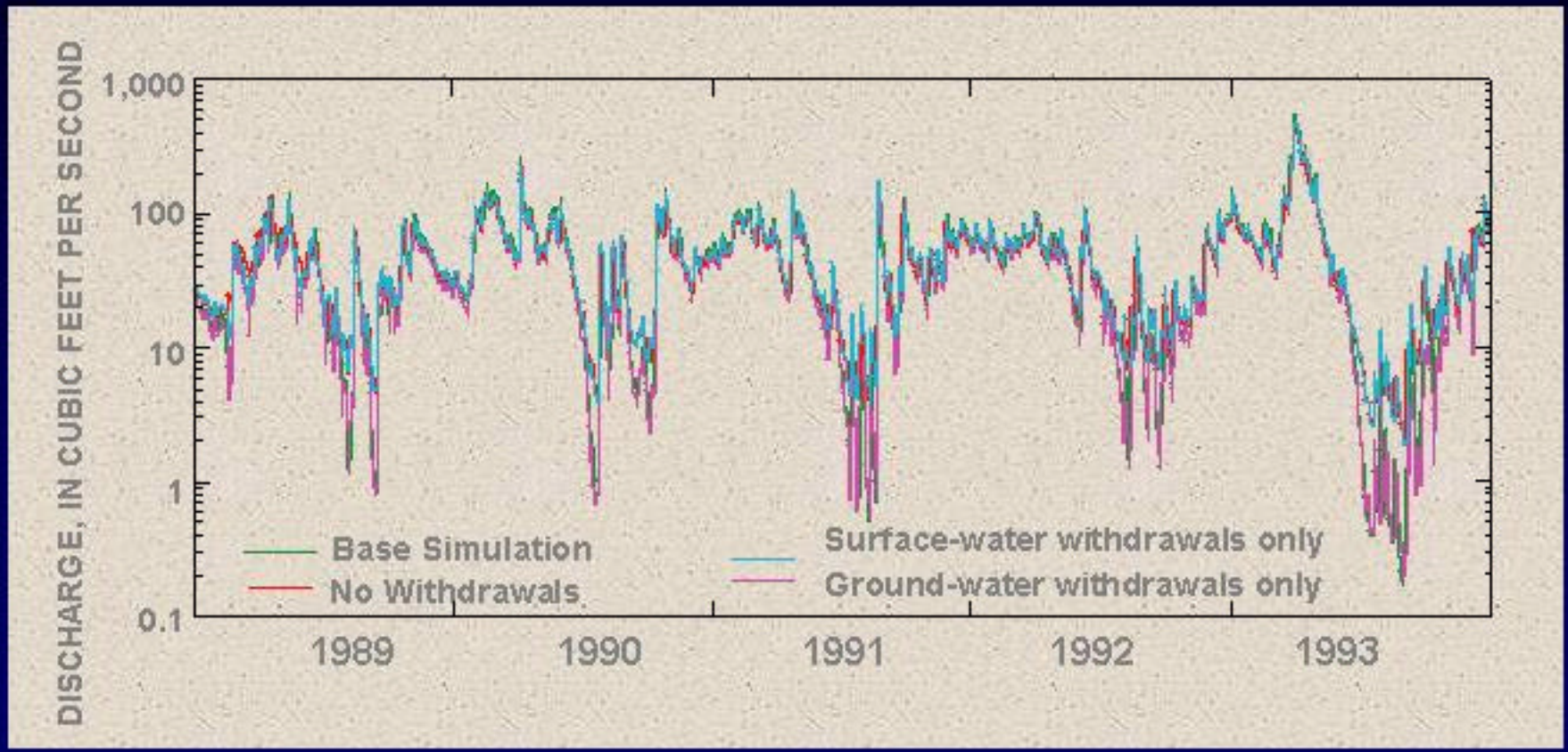


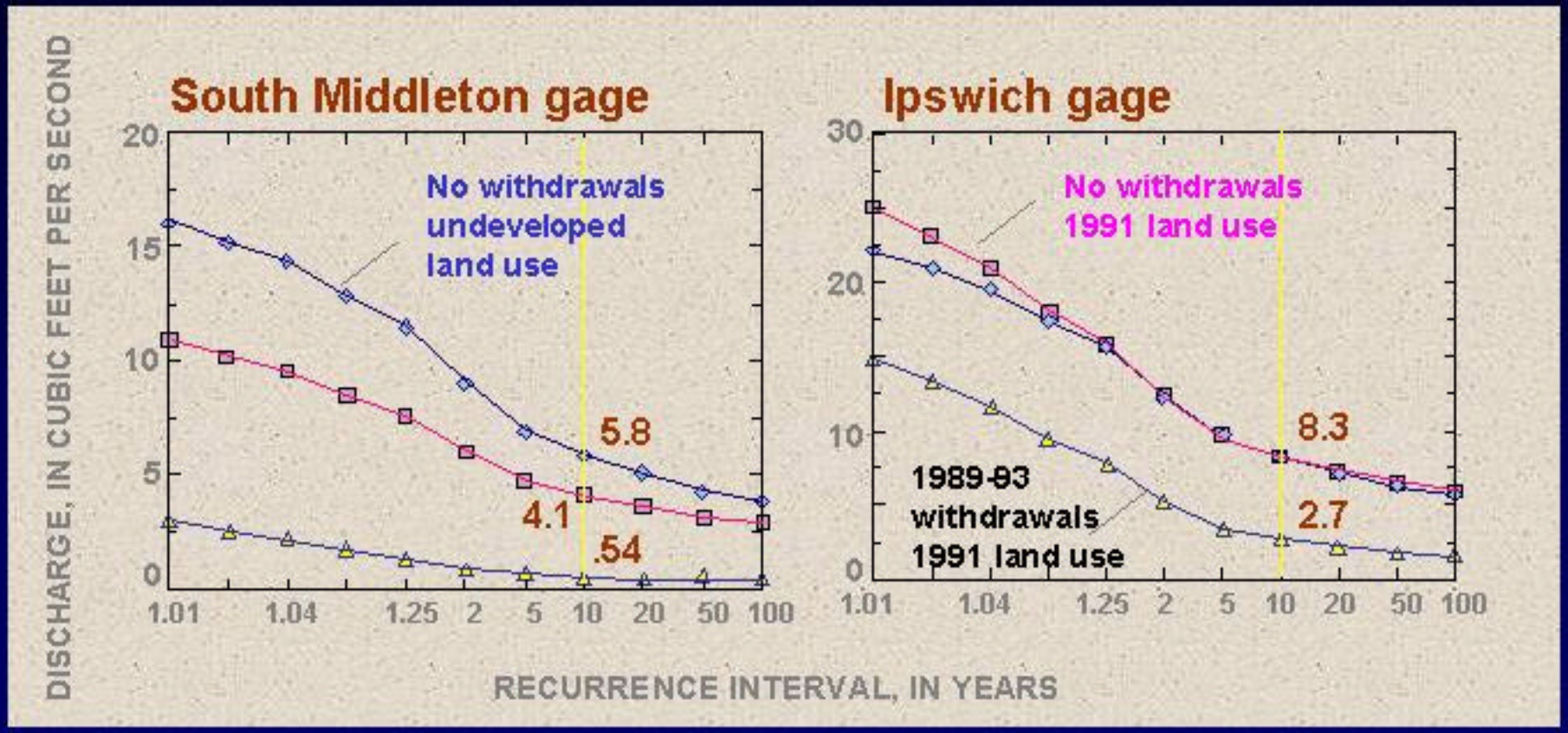
Hydrographs - Scenarios 1-3

1989-93 Calibration period, South Middleton



Log-Pearson Type-III 7-Day Low-Flow

Long-term Simulations (1961-95): Scenarios 4-6



What was learned?

- Difference between low-flows with and without ground-water withdrawals is about an order of magnitude different
- Surface-water withdrawals have little effect on low flows because of the water-use permit restrictions currently in place

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Documented in USGS report:

A Precipitation-Runoff Model for the Analysis of the Effects of Water Withdrawals on Streamflow, Ipswich River Basin, Massachusetts

USGS Water Resources Investigation Report 00-4029

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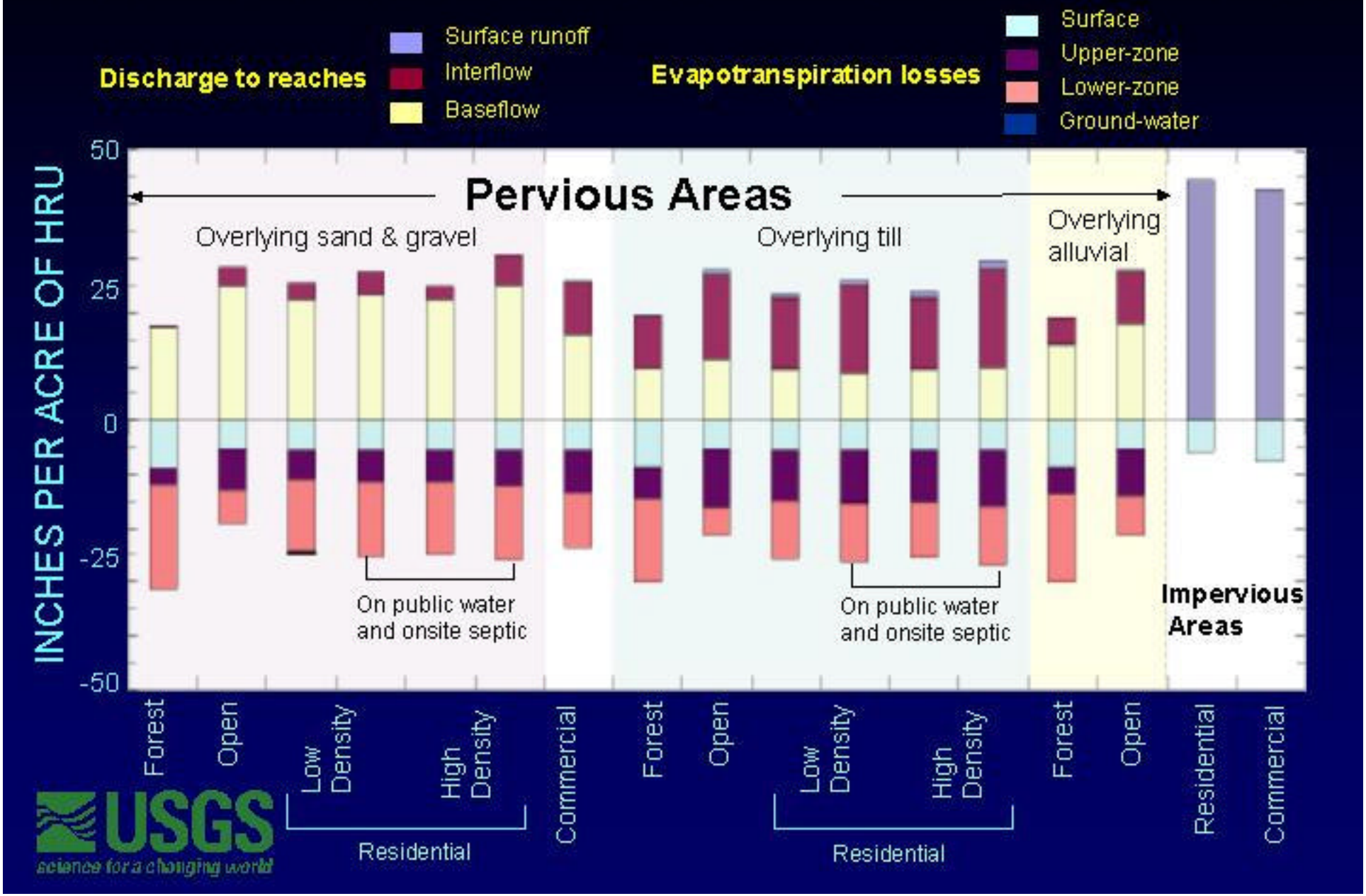
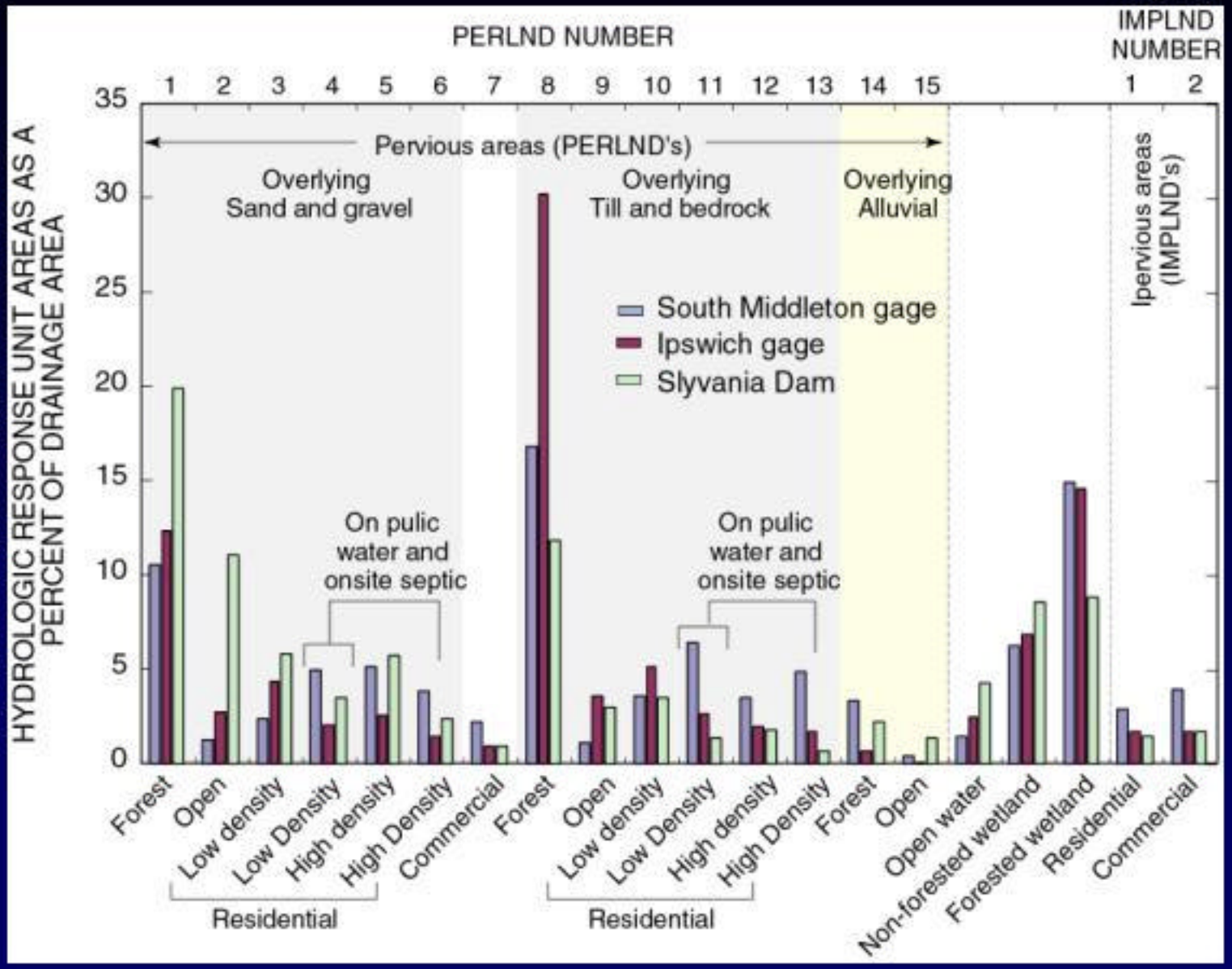
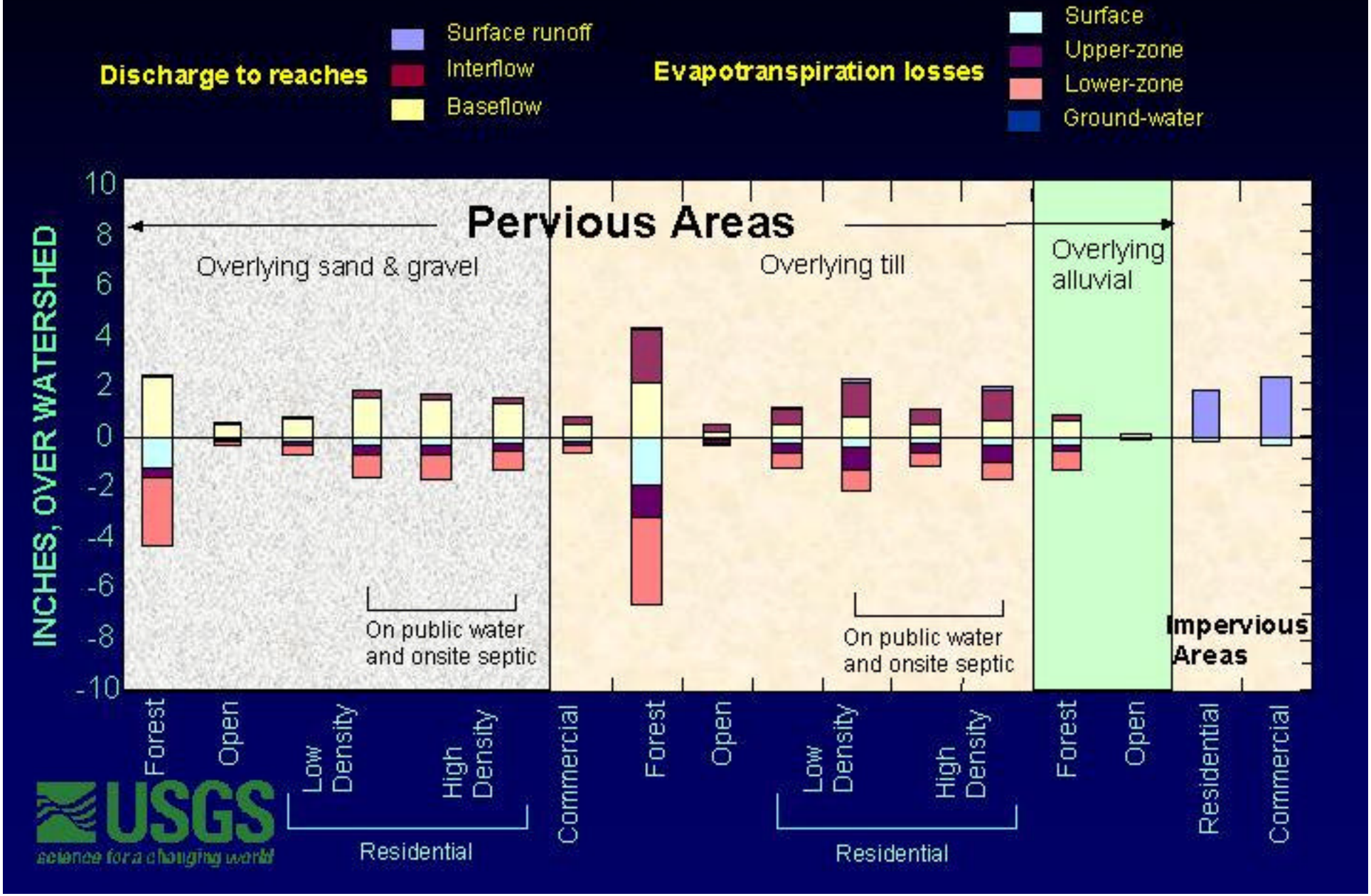
Average Annual Water Budget Components 1989-93



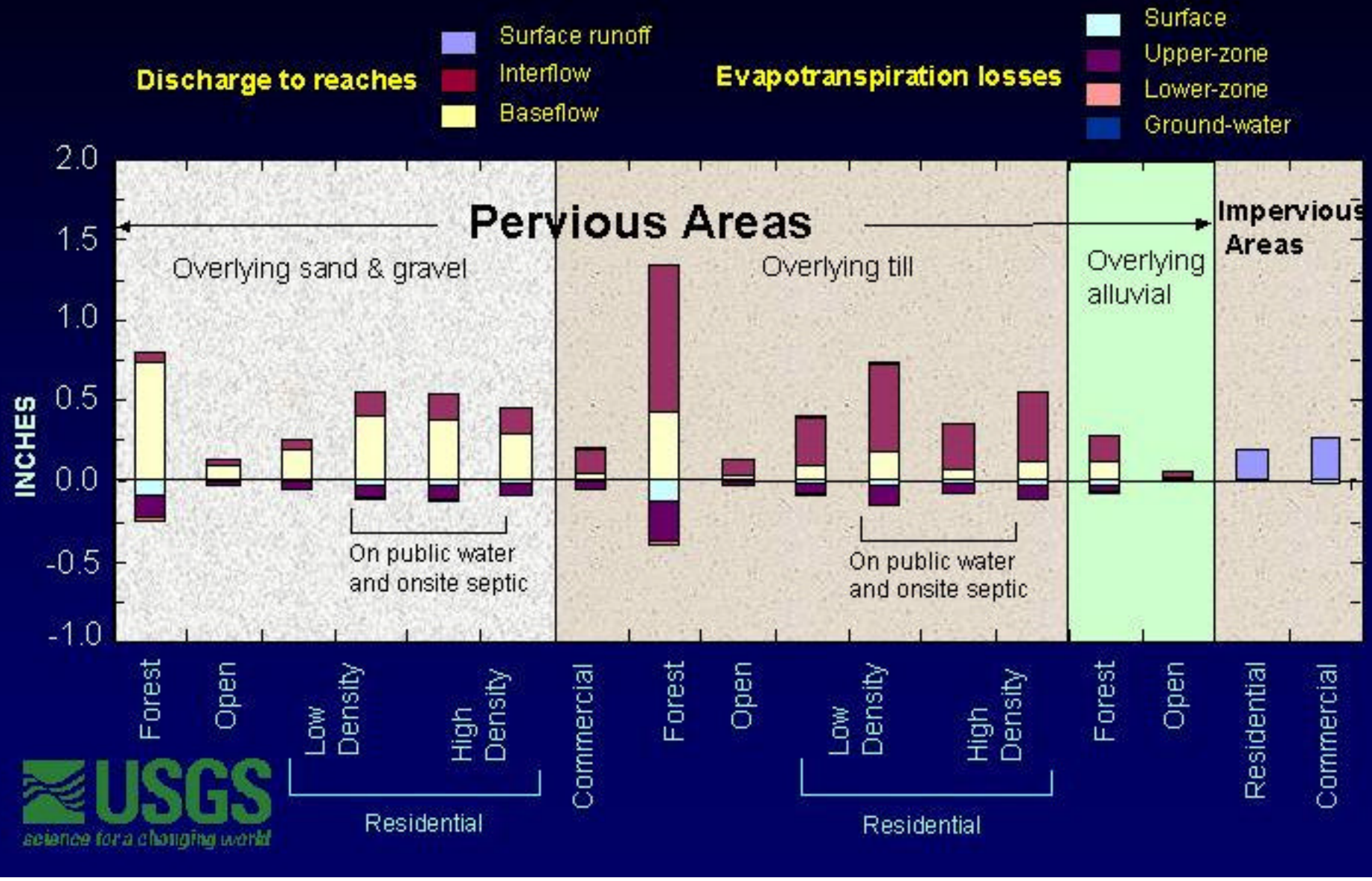
Hydrological Response Units

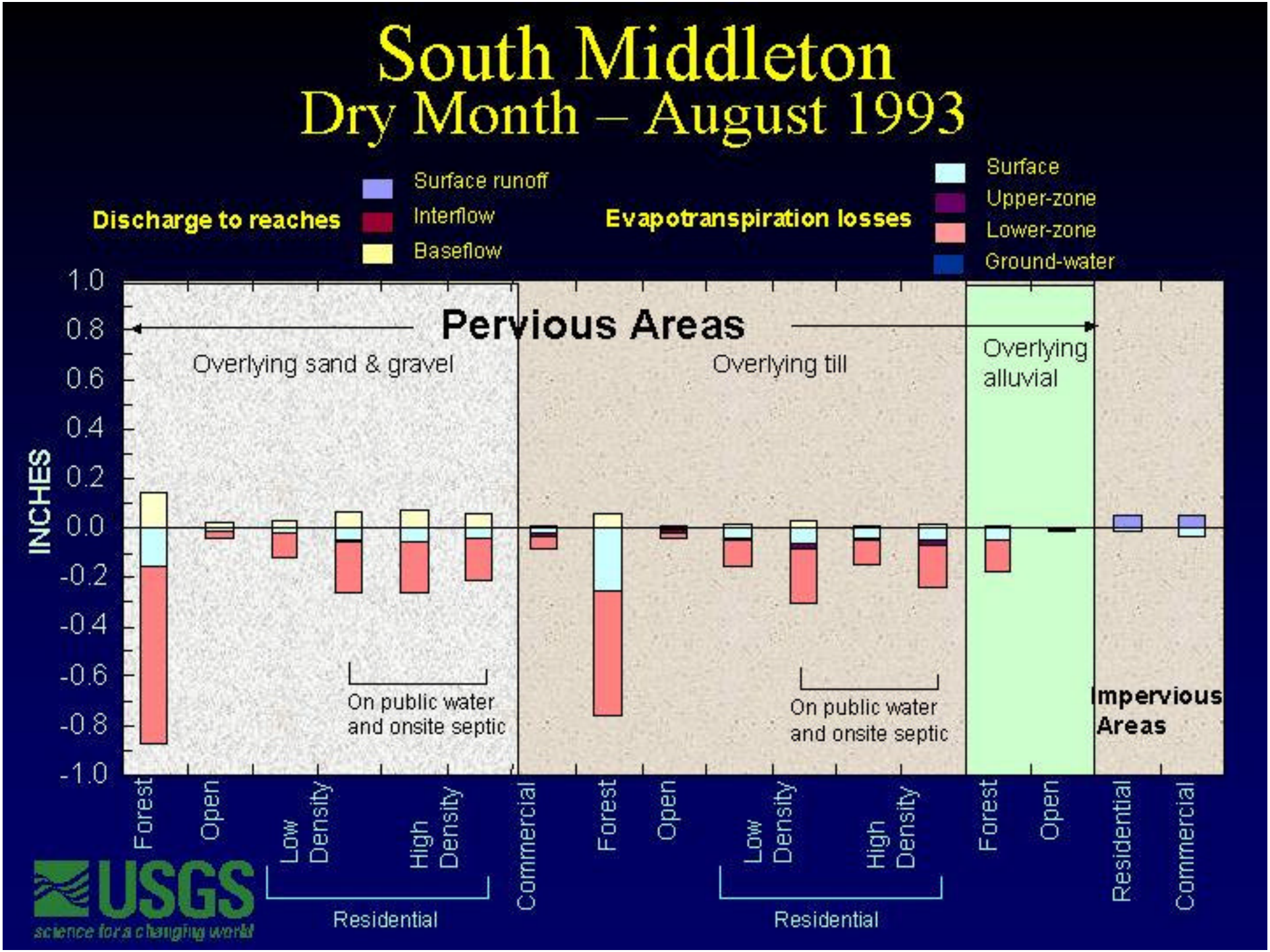


Mean Annual Water Budgets – South Middleton



South Middleton
Wet Month – April 1993




South Middleton
Dry Month – August 1993
Discharge to reaches
Surface runoff
Interflow
Baseflow
Evapotranspiration losses
Surface
Upper-zone
Lower-zone
Ground-water
INCHES
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
Pervious Areas
Overlying sand & gravel
Overlying till
Overlying alluvial
On public water and onsite septic
On public water and onsite septic
Impervious Areas
Forest
Open
Low Density
High Density
Residential
Commercial
Forest
Open
Low Density
High Density
Residential
Forest
Open
Residential
Commercial
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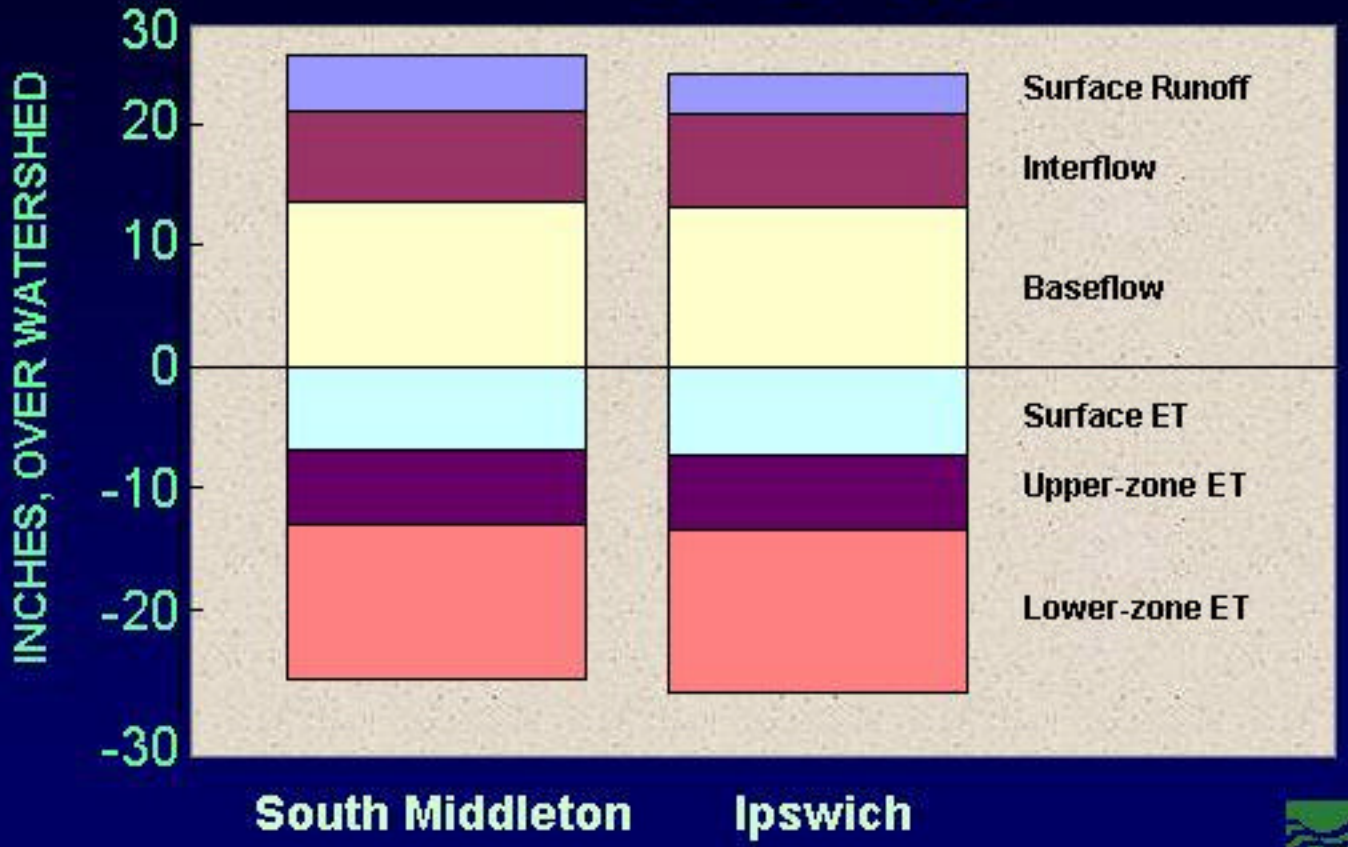
Components of the Annual Water Budget 1989-93



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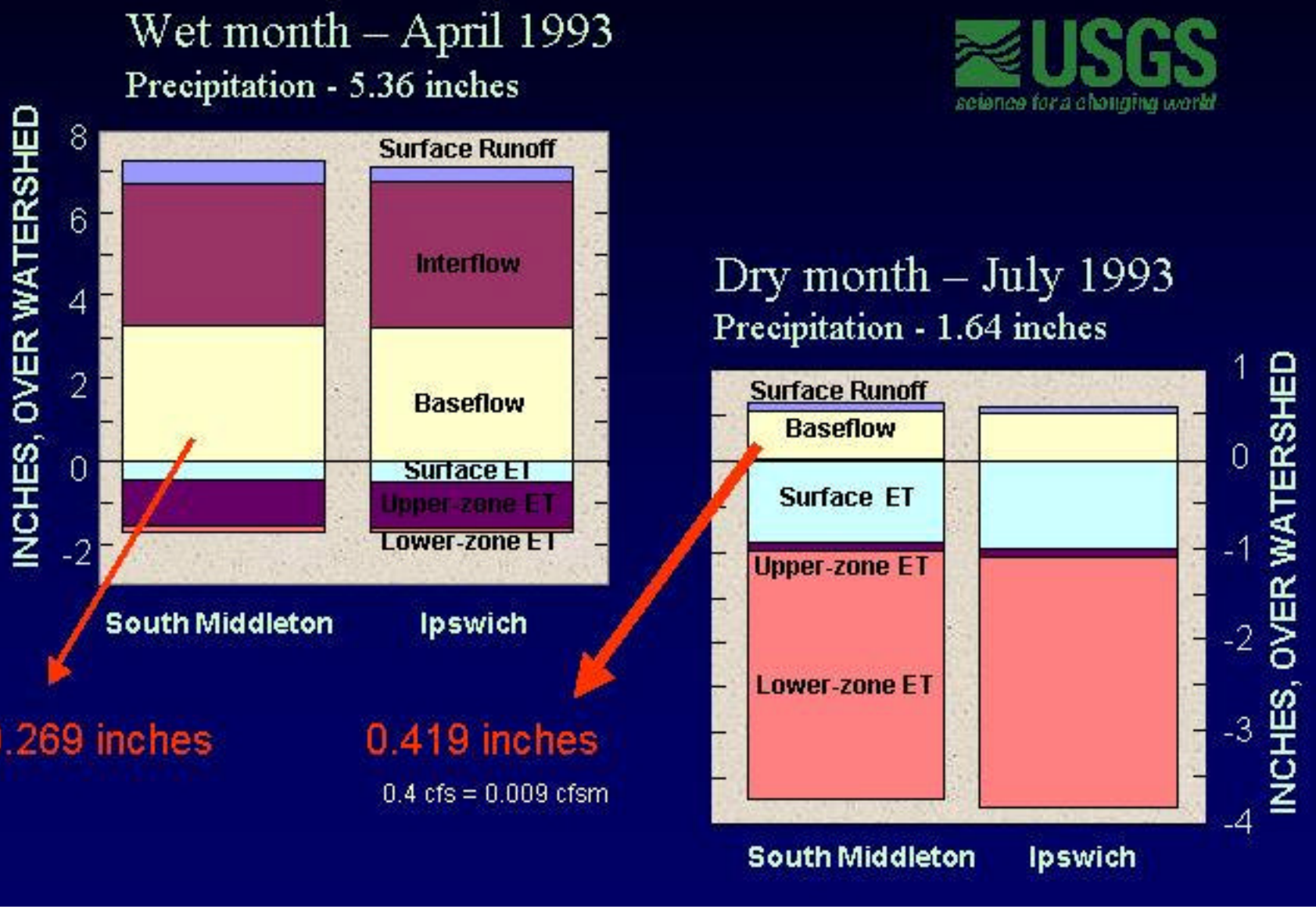
Monthly Water Budget Components



Water Management Alternatives

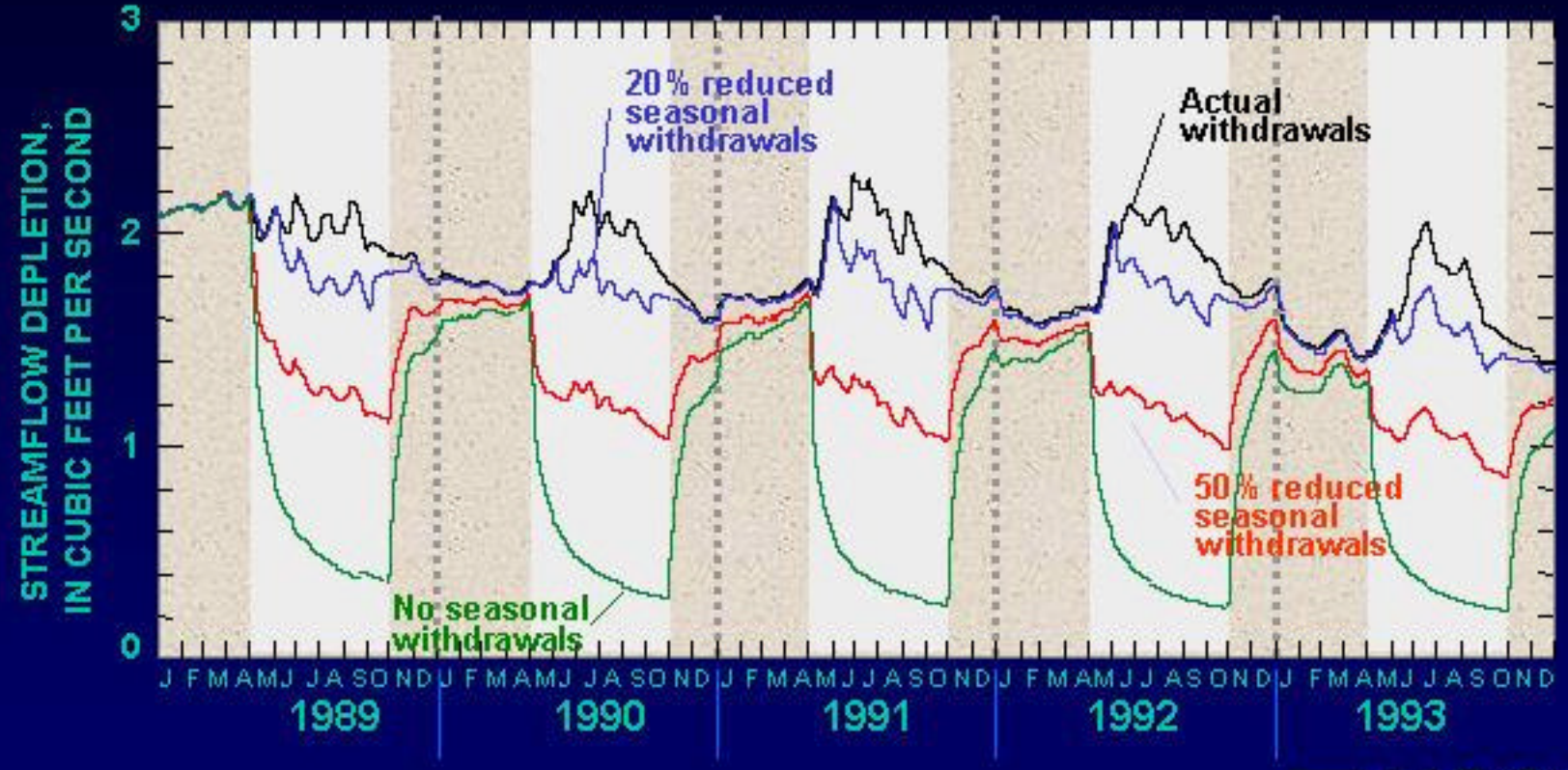
- No Seasonal withdrawals May 1 to October 31
- Reduce seasonal withdrawals by 50%
- Reduce seasonal withdrawals by 20%
- Stopping withdrawals below flow threshold

- Return wastewater at 4 sites at 1.1 Mgal/d
- Return wastewater at 4 sites at 1.7 Mgal/d
- Return wastewater at 1 site at 1.5 Mgal/d
- Effects of sewering

- Reduced seasonal withdrawals and sewering
- Reduced seasonal withdrawals and 2.6 Mgal/d return flow

Water-supply Management Simulations

Streamflow depletion rates



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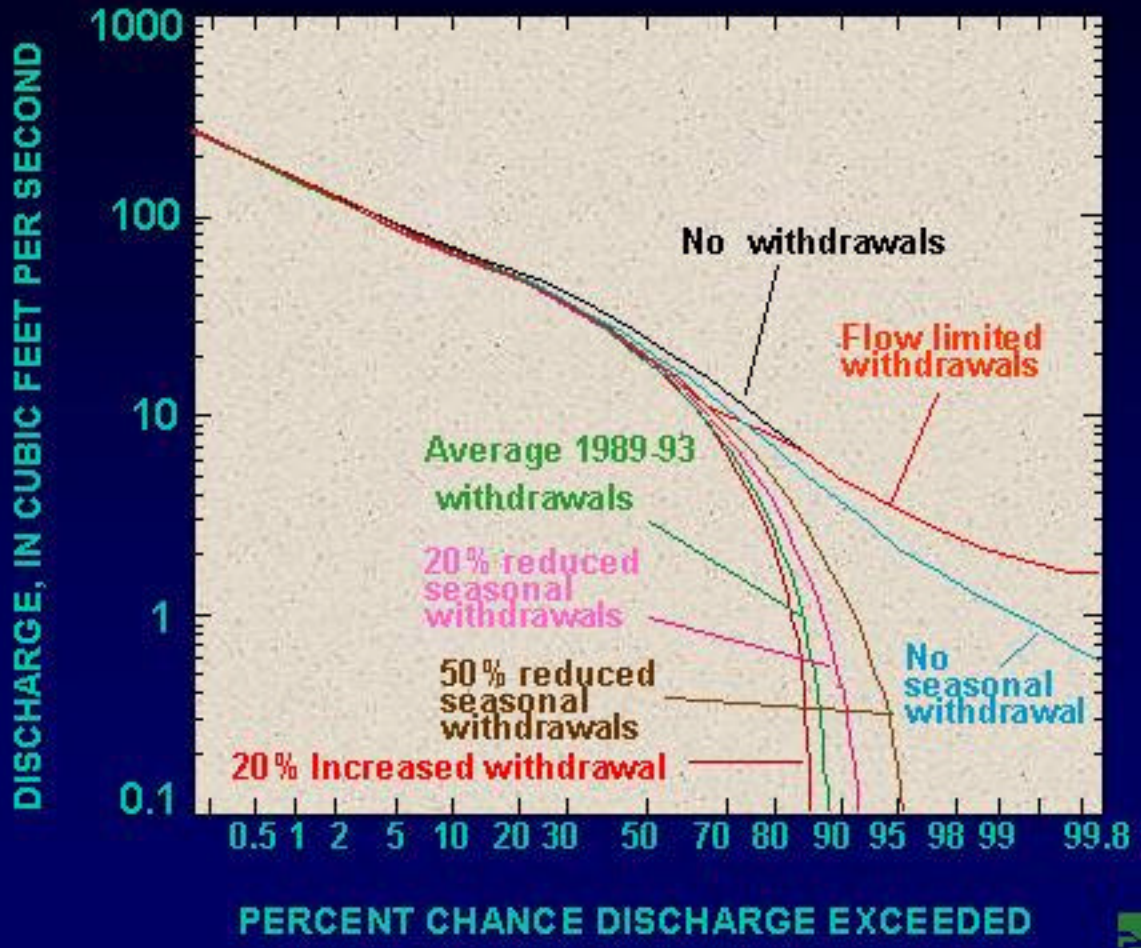
FLOW DURATION - RCHRES 8

Water supply simulations



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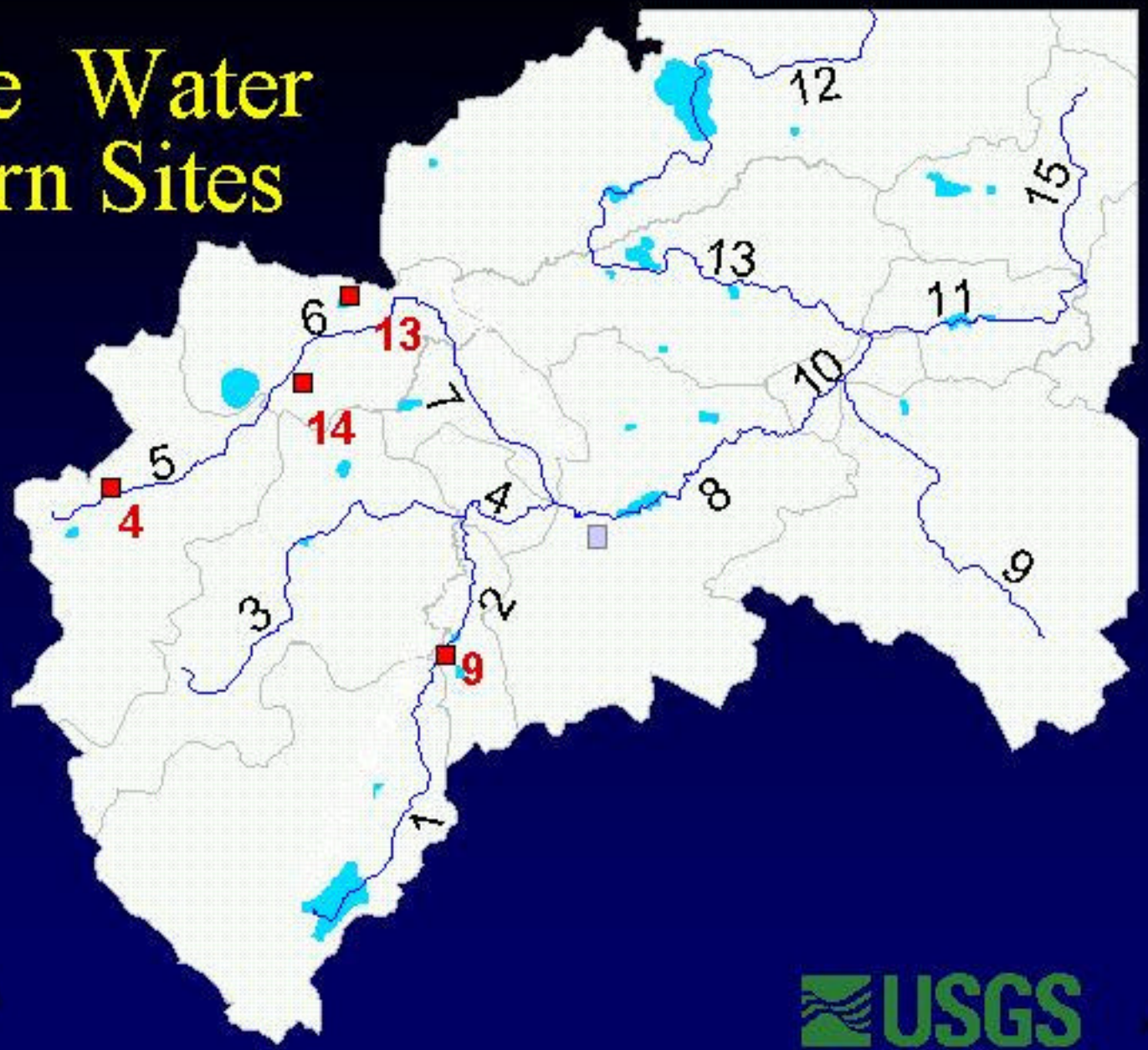
Waste Water Return Sites



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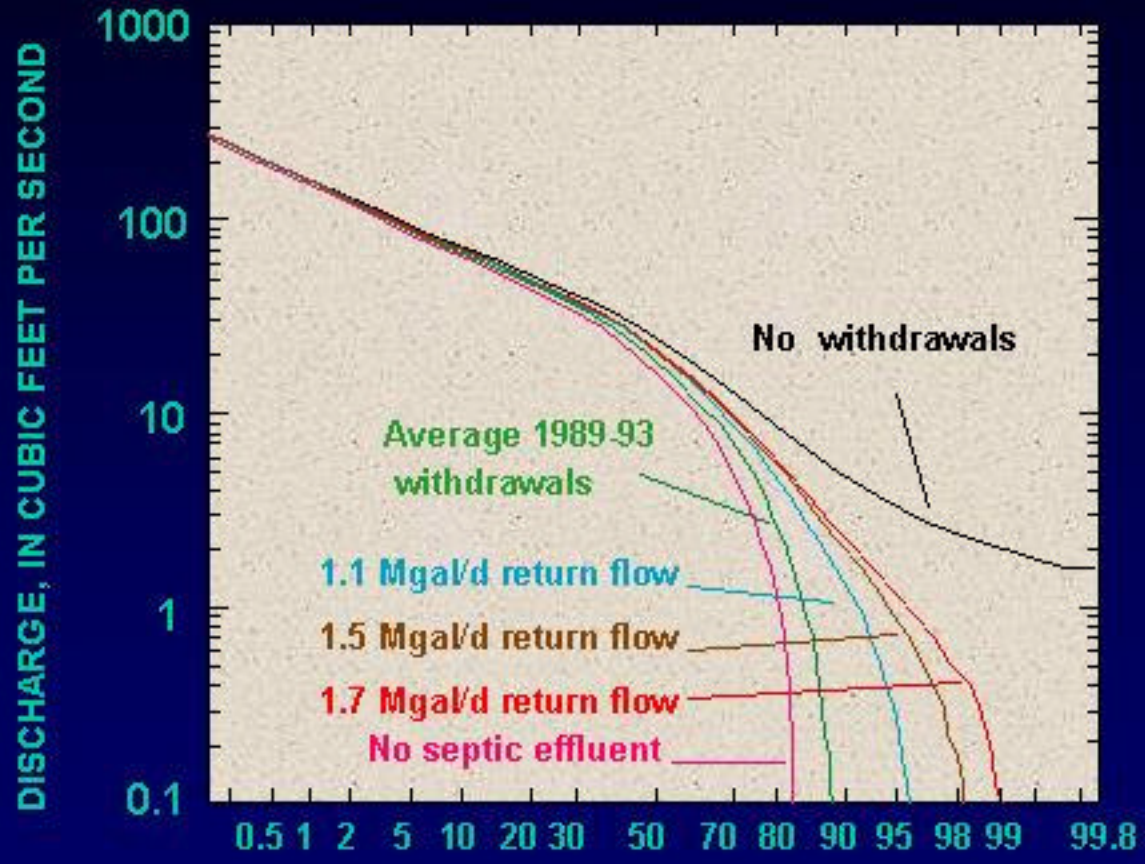
FLOW DURATION - RCHRES 8

Wastewater management simulations



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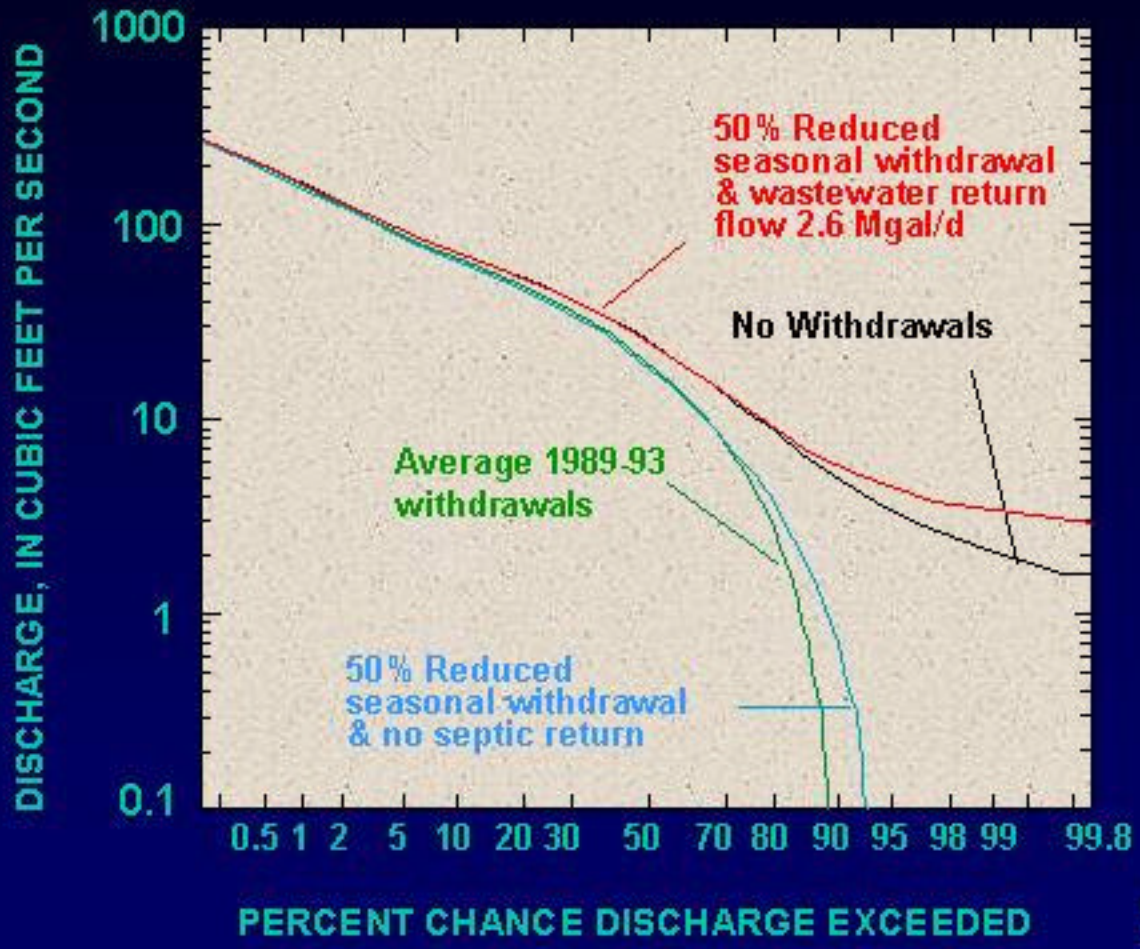
FLOW DURATION - RCHRES 8

Combined water supply and wastewater management



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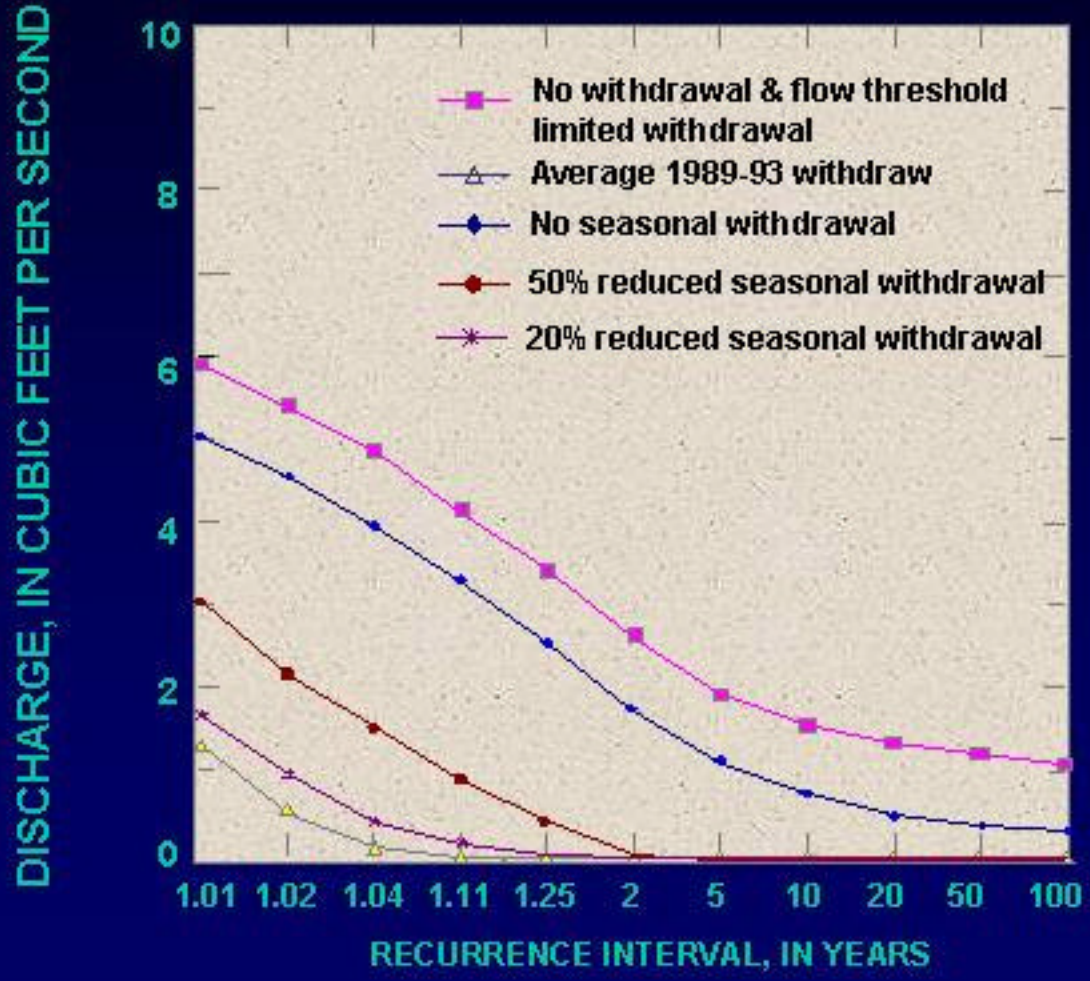
7-Day Low-Flow Frequency- RCHRES 8

Water supply simulations



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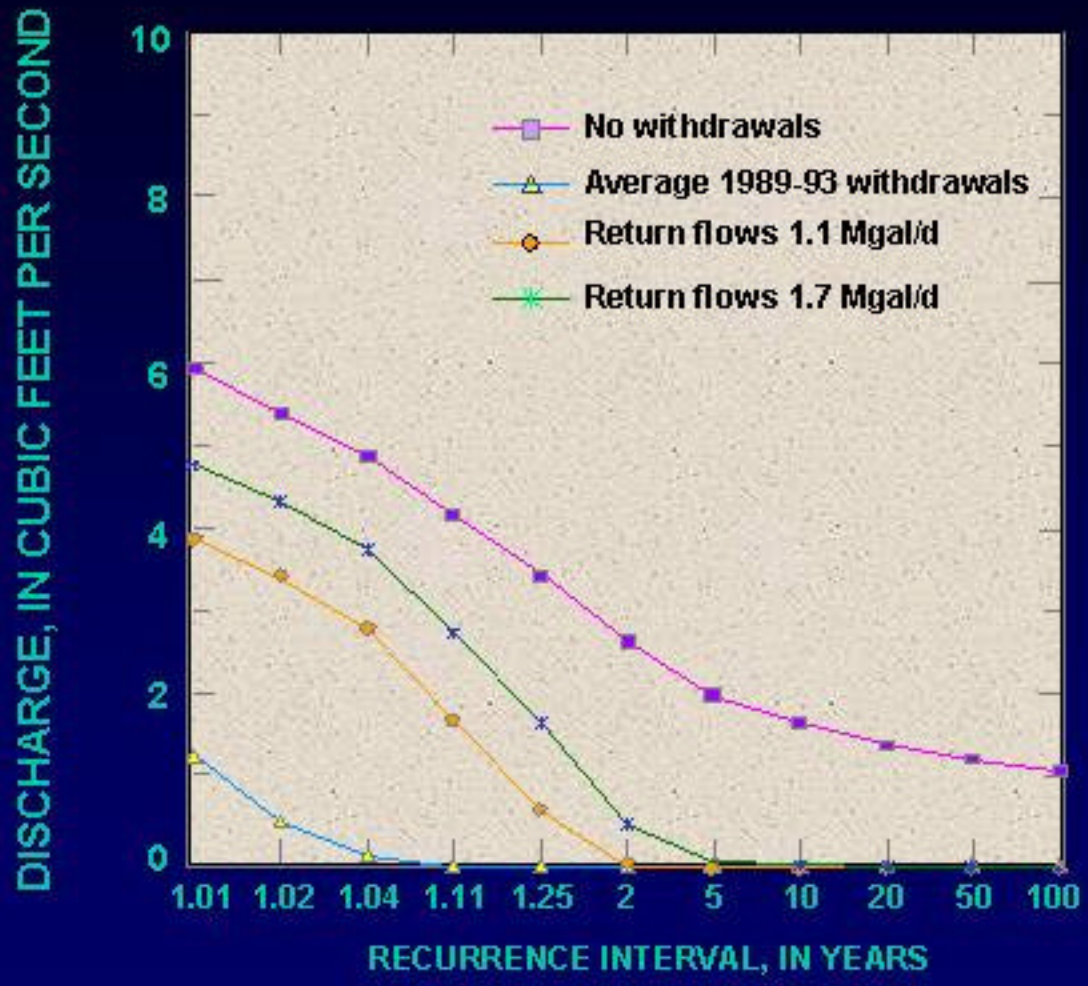
7-Day Low-Flow Frequency- RCHRES 8

Wastewater simulations



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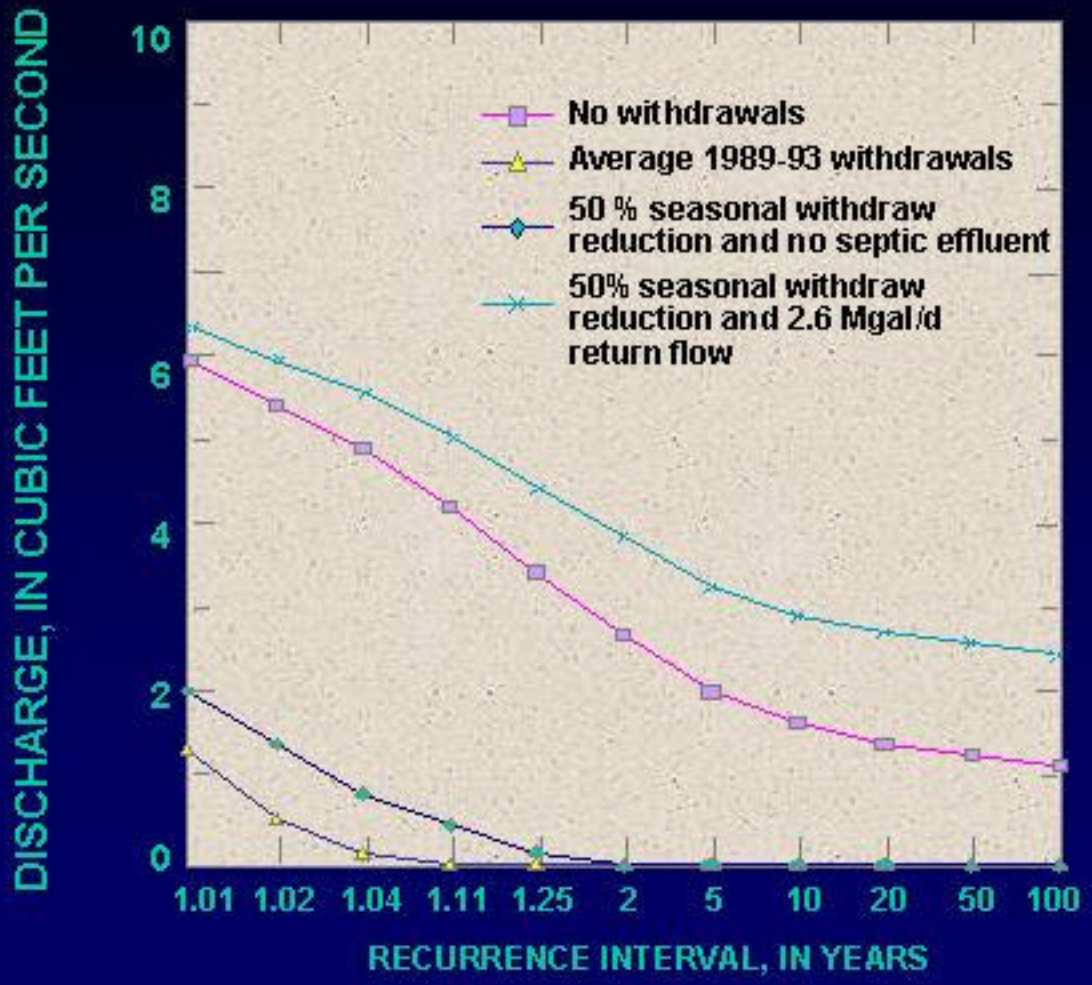
7-Day Low-Flow Frequency- RCHRES 8

Combined water supply and wastewater simulations



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What was Learned?

- Returning wastewater and reducing seasonal withdrawals can restore low flows to "natural" levels or better.
- Reducing seasonal withdrawals alone have only a modest benefit to low-flow restoration

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Summarized in USGS report

Effects of Water-Management Alternatives on Streamflow in the Ipswich River Basin, Massachusetts

USGS Open-File Report 01-483

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Firm-Yield of Surface-Water Supplies using the Ipswich River

Estimate the maximum withdrawal rate that can be sustained during a severe drought (Safe Yield)

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OBJECTIVES:

- Determine the firm yield of three surface-water supply systems under
  A. Permitted withdrawal restrictions and
  B. Restrictions recommended by
     Ipswich River Fisheries Restoration Task Group
- Evaluate reservoir storage of the systems under these withdrawal restrictions and recent water demands

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Ipswich River Basin

Permitted Withdrawals

December 1 and May 31

- Lynn—
  Discharge at South Middleton > 10 Mgal/d (15 ft^3/s)
  Annual limit 1,076 Mgal from Ipswich River (956 Mgal permitted + 120 Mgal supplemental)
  and 3,259 Mgal from the Saugus River
  Saugus River- No minimum streamflow requirements

- Peabody—
  Discharge at South Middleton > 15 Mgal/d (23 ft^3/s)
  Annual limit 1,500 Mgal

- Salem-Beverly—
  Discharge at Ipswich > 28 Mgal/d (43 ft^3/s)
  Annual limit 4,128 Mgal

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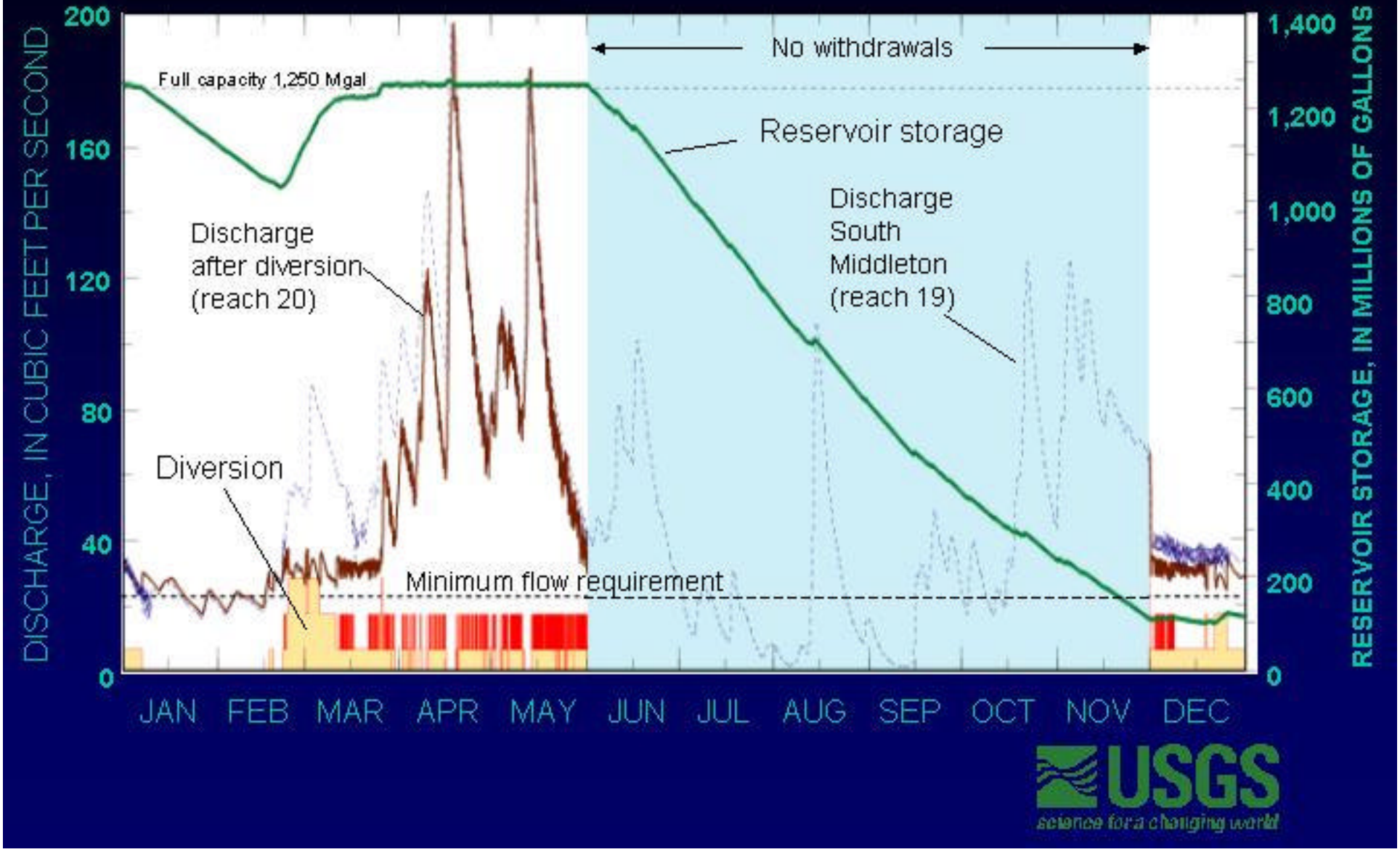
Peabody – permitted withdrawals



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Hypothetical Withdrawal Restrictions

Recommended streamflow requirements by Ipswich River Fisheries Task Group

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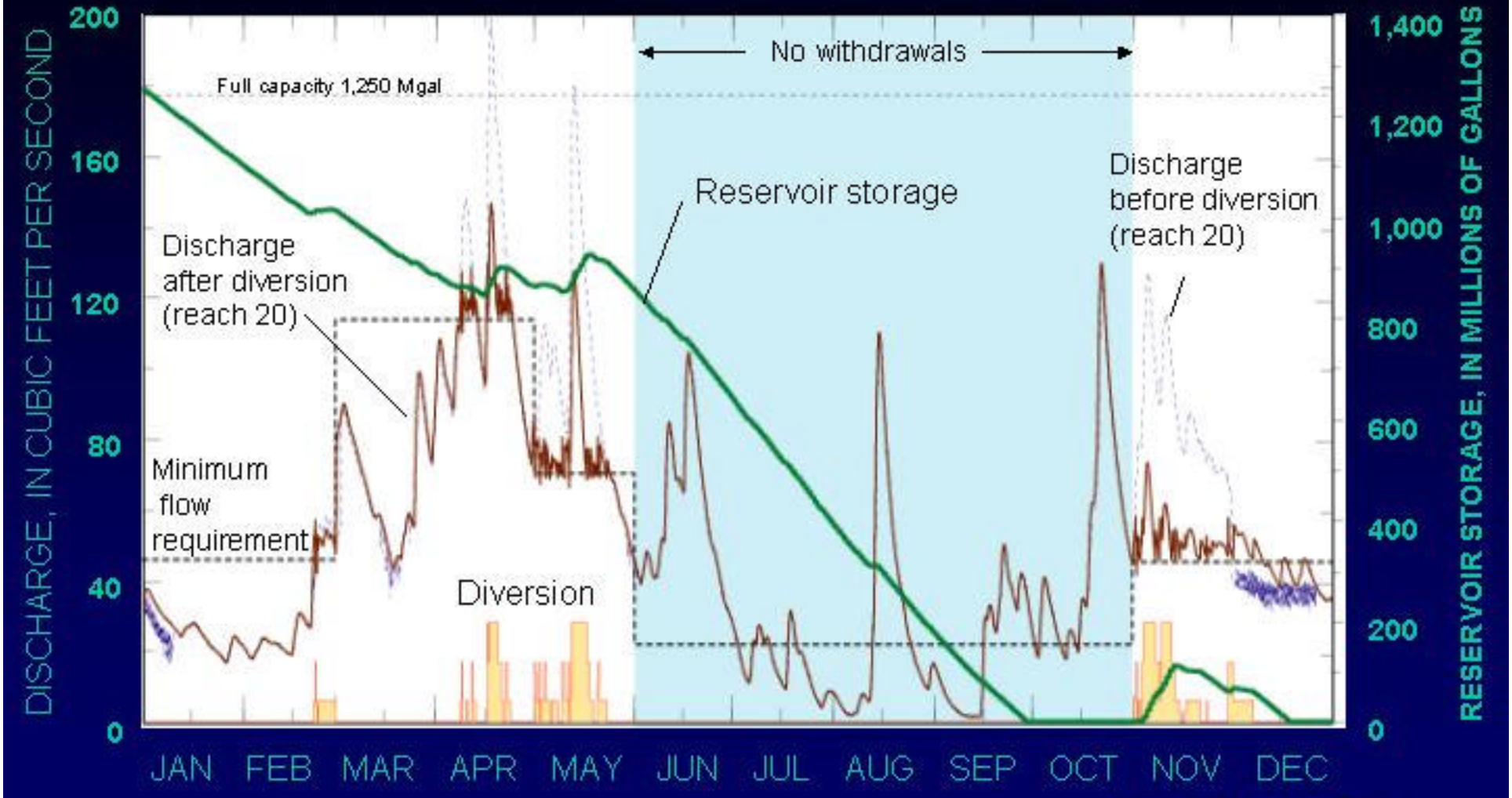
Time of year	Flow (cfsm)	Flow required at intake (ft^3/s)		
		Lynn	Peabody	Salem-Beverly
Drainage area		43.8 mi^2	45.6 mi^2	100 mi^2
Jun-Oct*	0.49	21	22	49
Nov-Feb	1.0	44	46	100
Mar-Apr	2.5	110	115	250
May	1.5	66	69	150

* Withdrawals not allowed

Lynn withdrawals from the Saugus River also simulated using Instream Flow Incremental Methodology (IFIM) study streamflow requirements; cfsm- 0.29 Jun-Sep, 0.57 Oct-Feb, 1.14 Mar-Apr, 0.95 May

Peabody – hypothetical restrictions



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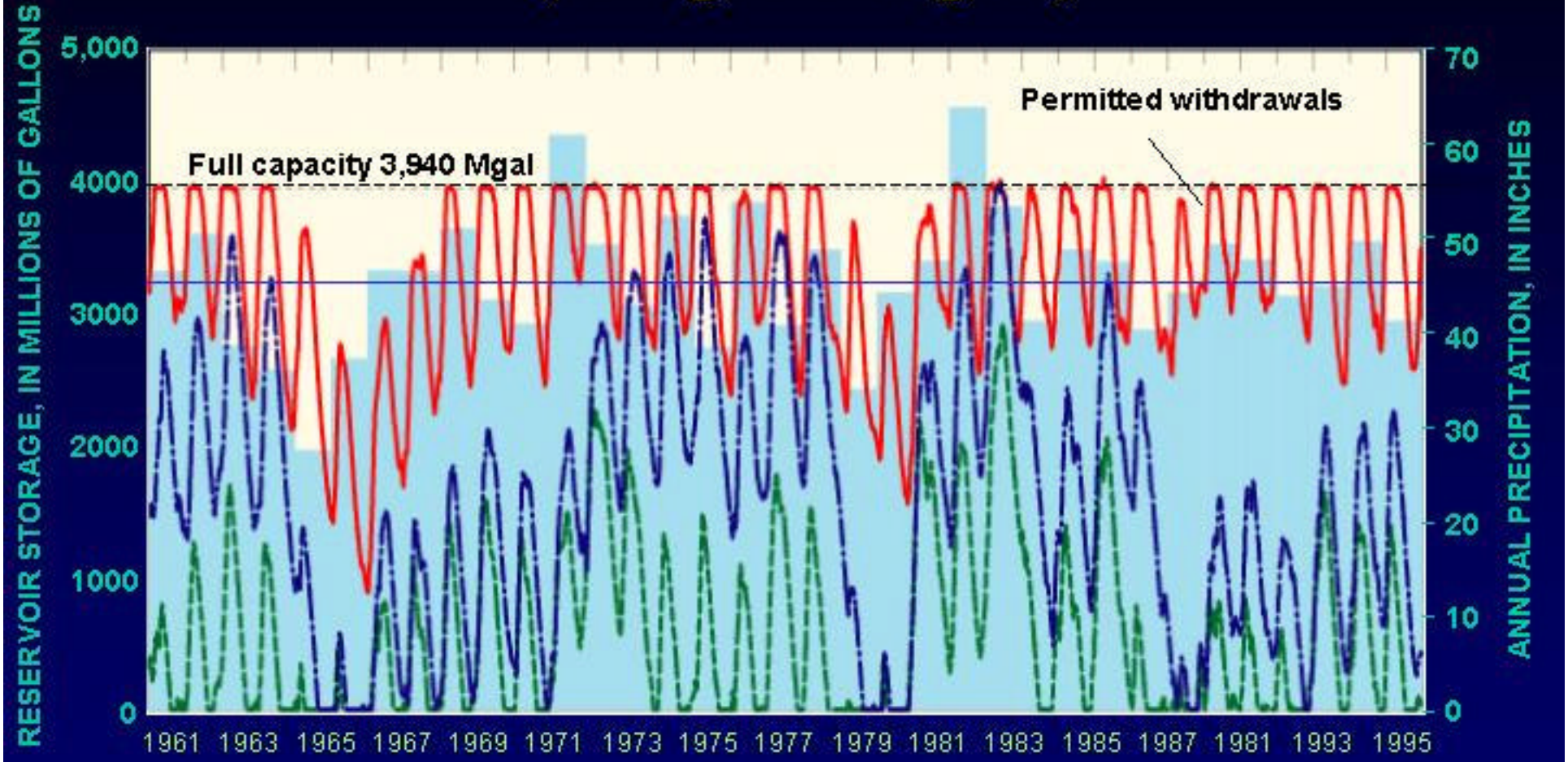
Lynn Supply System –
reservoir storage under 1998-2000 withdrawals (average 10.6 Mgal/d)



Lynn Supply System –

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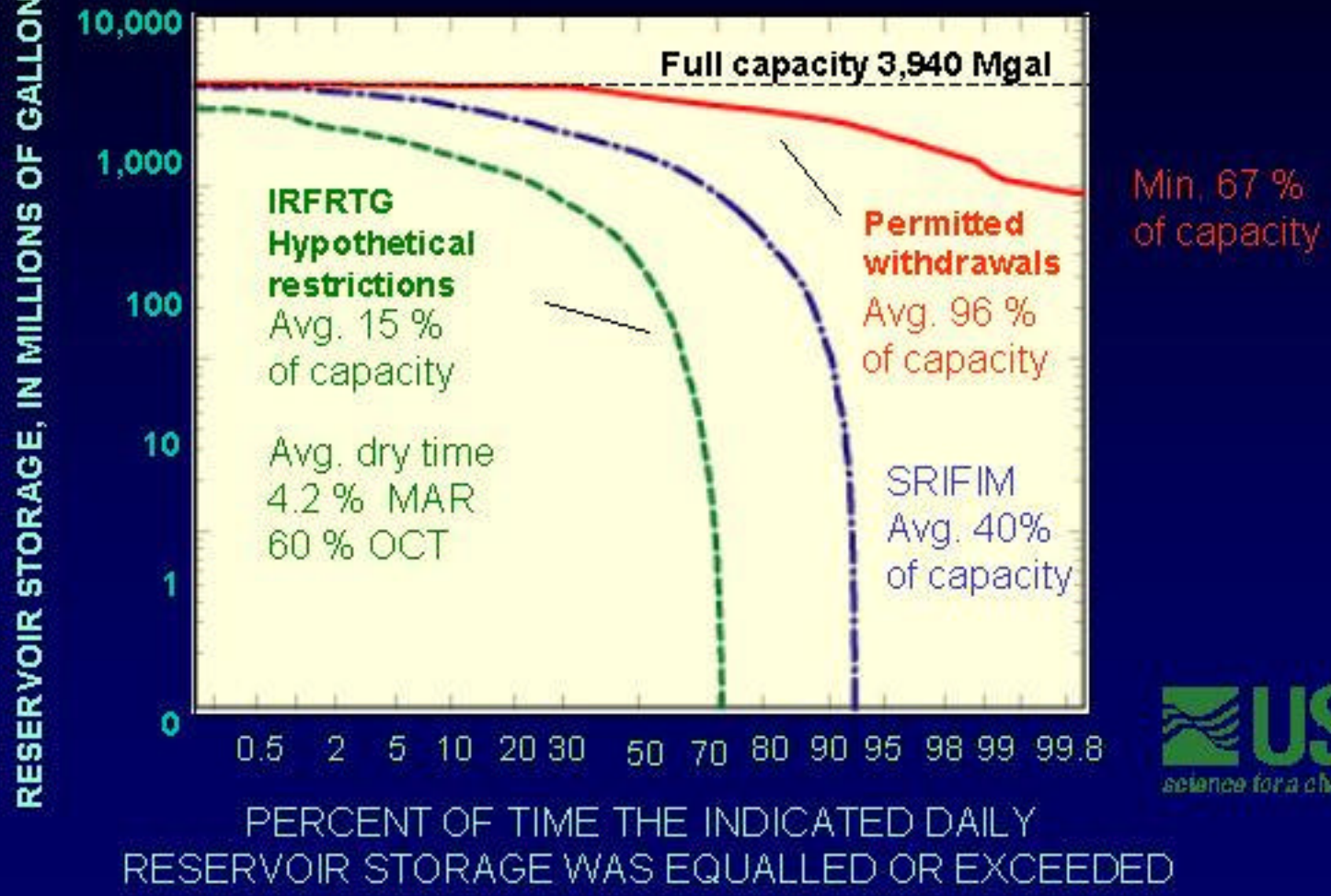

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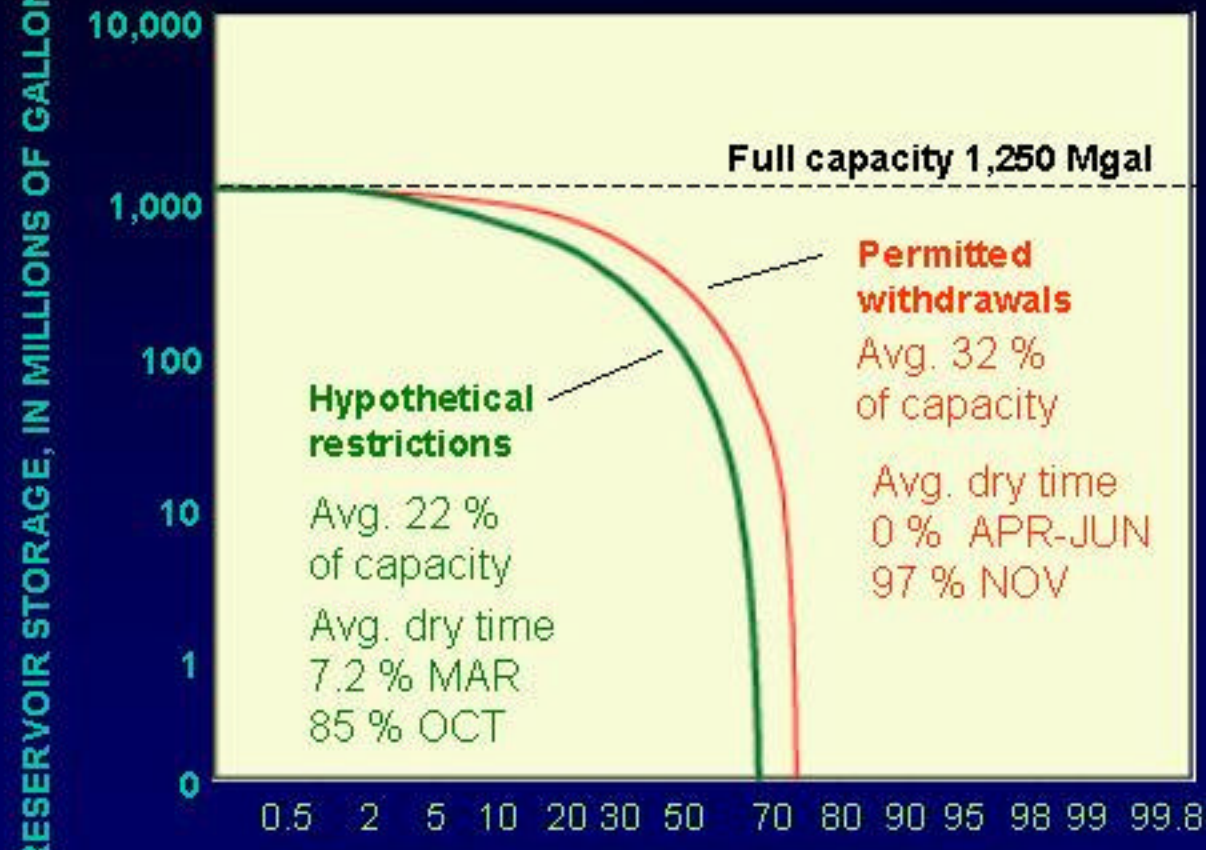
Peabody Supply System –

reservoir storage under 1998-2000 withdrawals (average 5.9 Mgal/d)



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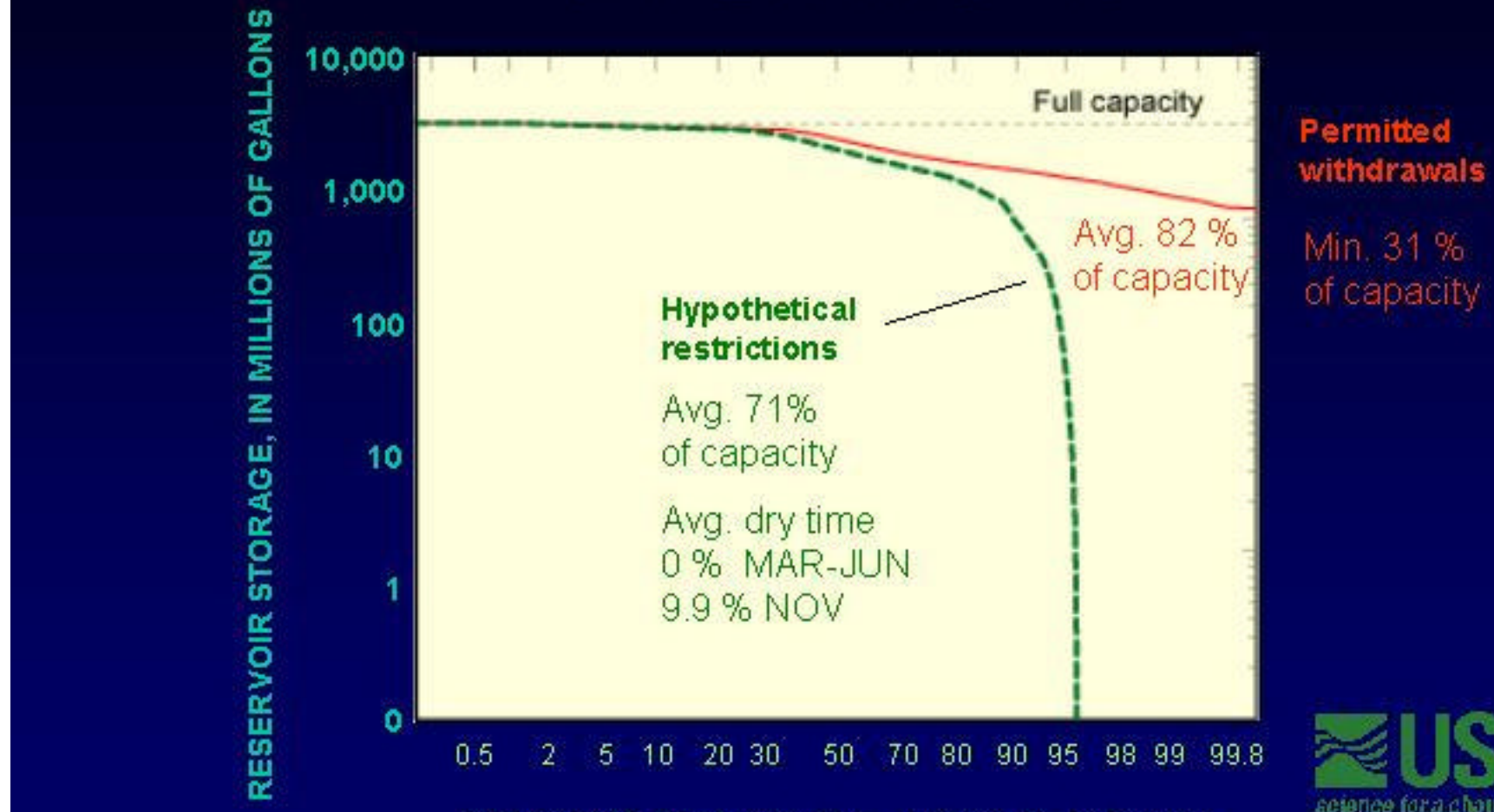
Salem-Beverly Supply System –

reservoir storage under 1998-2000 withdrawals (average 5.9 Mgal/d)



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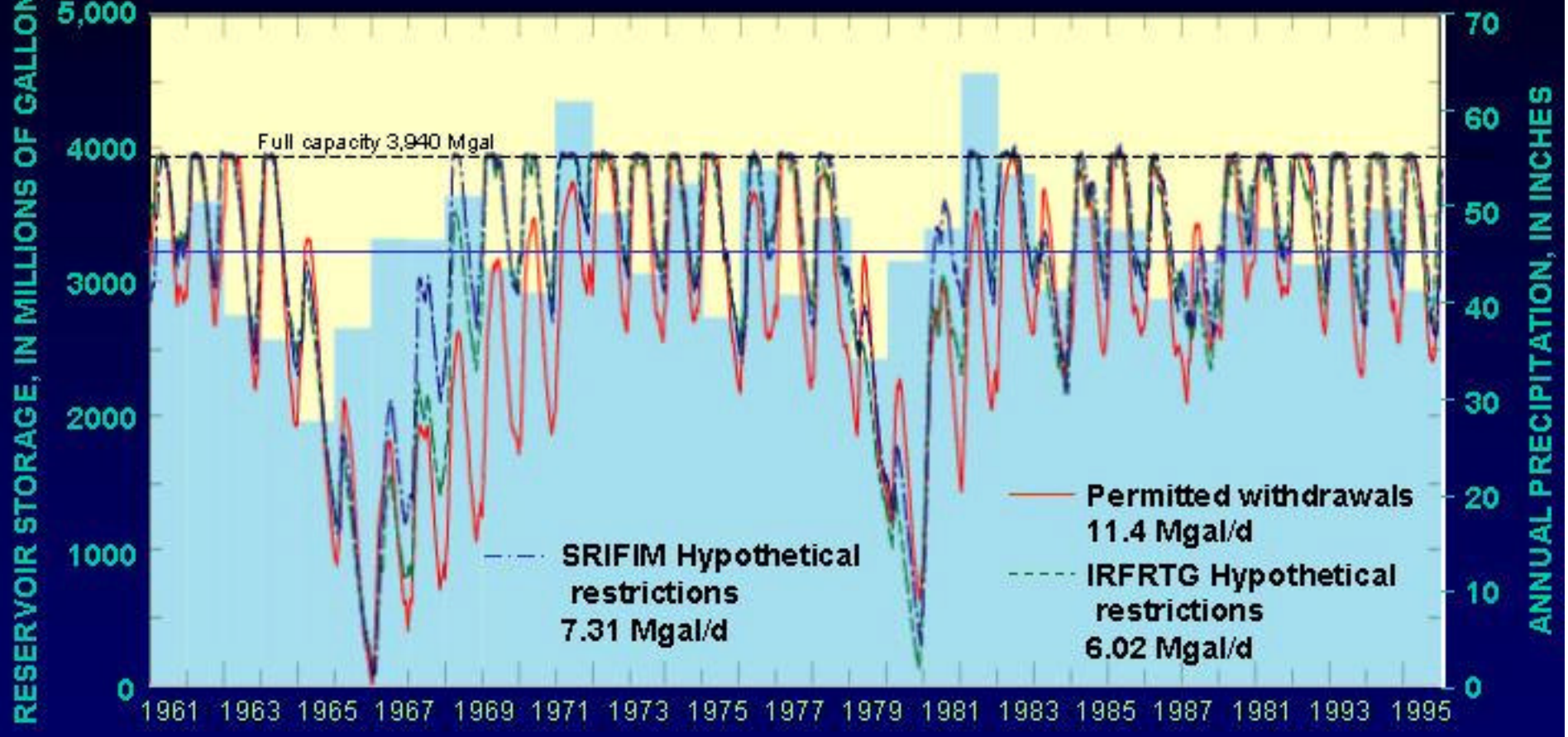
Lynn Supply System –

Firm-Yield Withdrawal



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Firm-Yield Estimates

Supplier	Average 1998-2000 demands Mgal/d	Permitted		Hypothetical	
		Firm yield Mgal/d	Percent change from 1998-00	Firm yield Mgal/d	Percent change From 1998-00
Lynn	10.6	11.4	8.0	6.02	-43
SRIFIM				7.31	-31
Peabody	5.88	3.70	-37	1.94	-67
Salem-Beverly	10.1	12.2	21	7.69	-24
Total	26.6	27.3	3.0	15.6	-41

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What was Learned?

- Peabody was unable to meet demands under permitted restrictions; Lynn and Salem-Beverly could increase withdrawals under permitted restrictions
- Demands could not meet under hypothetical restrictions

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Does the model provide a tool to better understand affects of water use on streamflow and management alternatives?

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PADDEL

~~PEDAL~~ ^ TO THE SEA…

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ON THE IPSWI